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Report of the Sub Group on Management Objectives and Strategies (EU STECF SGMOS-10-06). Report Part e) Evaluation of multi-annual plan for Baltic cod. Vigo (ESP), 18-22 October 2010

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Scientific, Technical and Economic Committee for Fisheries (STECF)

Report of the Sub Group on Management Objectives and Strategies (SGMOS 10-06). Part e) Evaluation of multi-annual plan for Baltic cod

18-22 OCTOBER 2010, VIGO

Edited by John Simmonds, Christopher Zimmermann, Margit Eero
Jörg Berkenhagen, Arina Motova, Rasmus Nielsen

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The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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TABLE OF CONTENTS

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

STECF COMMENTS ON THE REPORT OF THE SUB GROUP ON MANAGEMENT OBJECTIVES AND STRATEGIES (SGMOS 10-06). E) EVALUATION OF MULT-ANNUAL PLAN FOR BALTIC COD

STECF OPINION EXPRESSED DURING THE PLENARY MEETING (PLEN-10-02) HELD IN BRUSSELS, 8-12 NOVEMBER 2010

1. INTRODUCTION

STECF is requested to review the reports of the **SGMOS-10-06** Working Group of October 18 – 22, 2010 (Vigo) meeting, evaluate the findings and make any appropriate comments and recommendations.

When reviewing the SG-MOS 10-06b report, the STECF was asked to highlight limits faced when evaluating or assessing management options in terms of economic and social impacts. STECF will be also requested to suggest paths to reduce these limits, either by indicating possible assumptions which would be followed to make fisheries, metiérs and fleets matching better or by highlighting possible modifications to the list and to the level of aggregation of economic parameters listed in the DCF.

2. TERMS OF REFERENCE

The STECF (SG-MOS 10-06) is requested to

A) Evaluate the following plans:

1. Multi-annual plan for hake and Nephrops in ICES sub areas VIIIc and IXa
2. Multi-annual plan for cod in the Baltic

Following and taking into account *inter alia* the STECF framework specified in Annex C of SG-MOS 10-06a and WDs prepared by participants prior to the meeting. Separate reports should be prepared for each plan.

B) Provide an Impact Assessment of the following plans:

3. Multi-annual plan for sole in the Western Channel
4. Sole and plaice in the North Sea

by taking into account *inter alia*, the external report prepared by MRAG on assessing the impact for the revision multiannual plan for sole and plaice, WDs on sole and plaice prepared by IMARES, LEI, and WD prepared by CEFAS and Seafish on WC sole. The report should follow the STECF framework specified in Annex B of SG-MOS 10-06a. Separate reports should be prepared for each plan.

3. STECF COMMENTS AND CONCLUSIONS

Approach to the work

In line with the STECF process, described in the STECF-SGMOS 09-02 and STECF-SGMOS 10-01 WGs, STECF set up a scoping meeting SG-MOS 10-06a which was held in Copenhagen in June 2010. This group involved Commission staff, Observers and STECF experts. The scoping meeting produced a report (STECF-SGMOS 10-06a) which specified a series of work activities to be carried out before the October meeting. Following this Working Documents were prepared by participants for the main meeting which was held 18-22 October 2010 in Vigo, Spain. At this meeting there were 19 experts (6 economists and 13 biologists), Five Commission staff attended part time (including two from CFCA) and eight observers nominated by Baltic, NS, NWW and SWW RACs, Member States and ICES. The study group was open to observers throughout and their participation was regarded by the group as a particularly important part of this work. The working procedures were organised to facilitate observer participation by scheduling the presentation and discussion of topics on specific days to allow part time attendance if required. STECF is grateful for the input from observers.

Reports

In total five separate reports are prepared by STECF-SGMOS 10-06 WGs, the first, scoping meeting report STECF-SGMOS 10-06a was dealt with by the STECF summer plenary. The remaining four reports are deal with here:-

STECF-SGMOS 10-06b Report of the Impact Assessments for North Sea plaice and sole multiannual management.

STECF-SGMOS 10-06c Report of the Impact Assessments for Western Channel sole multiannual management.

STECF-SGMOS 10-06d. Report of the Evaluations of Southern hake and Nephrops Multi-annual plan

STECF-SG MOS 10-06e. Report of the Evaluations of Baltic cod Multi-annual plan

STECF provides below general comments and conclusions on this Evaluation the comments on other aspects of the ToR are included in the other reports (SGMOS 10-06b,c and d).

STECF Comments

There are a number of design issues associated with the wording of the plan, regarding the calculation of target F and changes to effort.

The biological considerations are provided separately of Eastern and Western stocks.

Eastern Baltic cod.

The management plan has in general been effective for the Eastern Baltic stock. Recruitment has been higher in recent years compared to the past 10 year's average. Since 2007 the compliance to management rules has improved resulting in reduced catch and reduced F.

Currently Eastern Baltic cod is estimated as being harvested a little below the current estimate of F_{msy} and this is expected to be maintained sustainably provided the management plan is complied with. This is considered to be the case under the full range of recruitment regimes observed in the past. There is no reason to believe that this will not be maintained until 2015 and beyond under the plan.

Western Baltic cod

In comparison to the eastern Baltic stock, the western Baltic stock has not shown any significant signs of recovery. The recent weak recruitment in combination with a reduced weight at age in the catch has resulted in the inability to reduce F as relatively larger numbers of individuals were required to provide the TAC.

Currently Western Baltic cod is being exploited above the F target of 0.6. Simulations suggest that the F target of 0.6 will be reached by 2015 provided there is compliance with the plan. The current estimate of F_{msy} is F=0.24. The current management target is not compatible with this in the long term.

Considerations for Impact Assessments

There is a range of additional aspects that should be considered if there is to be a major revision of cod management in the Baltic, such as: timing of spawning closures, inclusion of recreational fisher's catch; and unresolved biological issues involving mixing of the Baltic cod stocks, and migration. There are some concerns regarding the reduction in mean weight at age and the proportion of cod contributing to spawning for the older age groups in the Western Baltic stock. Future work or revisions to the plan should include continuity of these effects as a possible scenario along with developments returning to previously observed growth and recruitment. The scoping meeting should also consider published literature on multi-species interactions and management plan development in the Baltic. Collection of economic or transversal data should be organized so that it can be attributed to Eastern and Western stocks.

Annex 1 the report of the Sub Group on Management Objectives and Strategies (SGMOS 10-06). Part e) Evaluation of mult-annual plan for Baltic cod

Summary

THE SGMOS 10-06 met in Copenhagen in June 2010 and produced a scoping plan for the Evaluation of the Baltic cod multi-annual plan. The group met again in Vigo between 18-22 October 2010 and prepared this report for the November 2010 plenary of STECF. Based on the evaluation carried out the group came to the following conclusions:-

There are a number of design issues associated with the wording of the plan regarding year on year reduction targets and assumptions of effort links to fishing mortality that may not be sufficiently robust to implementation errors and data uncertainties.

The management plan has in general been effective for the eastern Baltic stock. Recruitment has been higher in recent years compared to the past 10 years average. Since 2007 the compliance to management rules has been increased resulting in reduced catch and reduced F.

In comparison to the eastern Baltic stock, the western Baltic stock has not shown any significant signs of recovery. The recent weak recruitment in combination with a reduced weight at age in the catch has resulted in the inability to reduce F as relatively larger numbers of individuals were required to provide the TAC.

Currently Eastern Baltic cod is being harvested a little below the current estimate of Fmsy and this is expected to be maintained sustainably provided the management plan is complied with. This is considered to be the case under the full range of recruitment regimes observed in the past. There is no reason to believe that this will not be maintained until 2015 and beyond under the plan.

Currently Western Baltic cod is being exploited above the F target of 0.6. Simulations suggest that the F target of 0.6 will be reached by 2015 provided there is compliance with the plan. The current estimate of Fmsy is F=0.24. The current management target is not compatible with this in the long term.

There is a range of additional aspects that should be considered if there is to be a major revision of cod management in the Baltic, such as: timing of spawning closures, inclusion of recreational fisher's catch; and unresolved biological issues involving mixing of the Baltic cod stocks, and migration. There are some concerns regarding the reduction in mean weight at age and the proportion of cod contributing to spawning for the older age groups in the Western Baltic stock. Future work or revisions to the plan should include continuity of these effects as a possible scenario along with developments returning to previously observed growth and recruitment. Collection of economic or transversal data should be organised so that it can be attributed to Eastern and Western stocks.

1. INTRODUCTION

This report is one of four prepared under SGMOS 10-06b, each dealing with a separate item on the ToR below. The work followed the plans from the Scoping meeting SGMOS 10-06a Copenhagen 7-11 June 2010. This report follows the structure defined by STECF which is given below in Annex A.

It forms a review of the practical implementation of the management plan considering the actions taken and measures implemented at the Member State level.

2. TERMS OF REFERENCE

The STECF (SG-MOS 10-06) is requested to

A) Evaluate the following plans:

1. Multi-annual plan for hake and Nephrops in ICES sub areas VIIIc and IXa

2. Multi-annual plan for cod in the Baltic

Following and taking into account *inter alia* the STECF framework specified in Annex C of SG-MOS 10-06a and WDs prepared by participants prior to the meeting. Separate reports should be prepared for each plan.

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The scoping meeting is reported in SG MOS 10-06a. The Impact Assessments are dealt with in reports SG-MOS 10-06 b, c and the Evaluation of hake and Nephrops in SG MOS 10-06 d.

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4. DESIGN ISSUES

The long-term management plan for both cod stocks in the Baltic Sea (Annex B) was implemented by January 1st, 2008 following a formal agreement of the Council of Minister's in summer 2007 (EC Reg. 1098/2007 published September 18th, 2007). However, TACs were set in the spirit of (but not exactly following) the proposed management plan already in the year before.

While the plan clearly defines the aim – to reduce fishing mortality for defined age groups to a level at or above 0.3 for the Eastern stock, and 0.6 for the Western stock – there are considerable ambiguities and a lack of definitions. To derive a TAC advice according to the management plan, and to evaluate the plan, ICES has had to make a number of assumptions, and there are some design issues which could potentially even lead to a failure of the plan:

- F in the "year of application" is considered to be the F in the prediction year, F in the "preceding year" is interpreted as the F in the interim year (the year where the recent assessment is conducted). Using a change based on an increment from a measured value from the previous year can lead to plan failure or to excessive reductions if errors in the assessment are in a consistent direction (retrospective bias). It would be preferable to specify a series of targets (F targets) by year so that both implementation and measurement error can be taken into account over time.

- Target F is factually not a target but a minimum value as the plan aims at keeping F above the target. In this respect, the plan failed for the Eastern Baltic cod as F is clearly below 0.3. There are however other rules described in the plan leading to a reduction of F to as close as possible to the targets inferring a target value.

- There is no rule described how effort should be regulated if F falls below target F. In the present situation, it is assumed that effort will not be further reduced once this happened and thus is actually frozen at the recent level. In this situation and with the limitation of a TAC deviation between years of 15%, it might not be possible in the medium term to increase F to be above F target.

- A core assumption of the plan is that fishing effort translates directly into fishing mortality, i.e. that a reduction of effort by 10% expressed as days-at-sea causes a reduction in F by 10%. This assumption is very difficult to defend as there are various ways to compensate a reduction in days-at-sea and keep the exerted effort unchanged.

The plan has been implemented in 2008 and not been updated since; the current process is expected to inform the first update.

The Baltic Cod long-term plan does not include multispecies considerations, although cod in the Baltic is to some extent – especially in the Western Baltic Sea caught in a multispecies fishery targeting flatfish in addition to cod and whiting in some metiers (Annex C). There are at present no other management plans implemented in the Baltic which could interfere with the cod long-term plan. However, there are issues in the design in relation to cod management plans in the neighbouring areas, namely the Kattegat: While the plan in the latter area defines effort as kW days, only days-at-sea are considered in the Baltic. This apparently leads to a displacement of capacity (engine power) from the Kattegat area to the Baltic for those fleets operating in both areas.

5. ENFORCEMENT AND COMPLIANCE

One of the major threats to a positive impact of the management plan was the amount of unallocated (or illegal) cod landings in the Eastern Baltic, which in some years added 35-45% to the reported landings (Figure 5.1). A significant amount of these additional landings were taken by the Polish fishery, as stated in the pay-back agreement between the EU and Poland in 2008 (EC Regulation 338/2008).

During 2005-2008 there was an increased awareness about the low compliance in the cod fisheries in the whole Baltic. Here the Baltic RAC, together with the commission, played an important role. The work done between national agencies, the Baltic RAC and the commission increased the awareness of the problem and resulted in the signature of the Copenhagen declaration to combat IUU fishing (Reference), and in an increased compliance. This discussion has resulted in an overall acceptance of the Multi-annual Plan.

In autumn 2007, a new government was elected in Poland. Within a month, the new government announced it would accept closures of eastern cod fishery by EC and after negotiation with the Commission developed a payback scheme to compensate illegal activities in the past. Following this agreement the government strengthened fisheries inspection services and developed fleet restructuring plan accepted by European Commission. These measures as well as others applied by Baltic States as the result of Copenhagen Declaration reduced the illegal overfishing from the Eastern cod stock to less than 10% (most recent estimate by the ICES WGBFAS is less than 6%, Fig 5.1).

Vessel Monitoring System (VMS) data on spatial allocation of effort in combination with corresponding allocation of landings can provide indications of possible area-misreporting of landings. Concerning Western Baltic, analyses of Danish VMS data (trawlers landing more than 25% of cod and fishing defined as a speed between 2-4 knots) from 2006-2009 indicate that in 2006, 16% of the VMS signals were recorded outside the Western Baltic when catches were reported in the Western Baltic (WGBFAS 2010; Fig. 5.2). Since 2006 the level of this mismatch has been decreasing and in 2009 less than 1% of the VMS signals where landings were reported to the Western Baltic were detected as coming from outside the area. The main part of the historic spatial mismatch between VMS signals and reported landings has been between Kattegat and the Western Baltic (Fig. 5.2). Improved compliance in this area implies that the reduction in catches of Western Baltic cod in recent years (Fig. 6.3) might in reality be smaller, as the landings in earlier years might have been lower than reported.

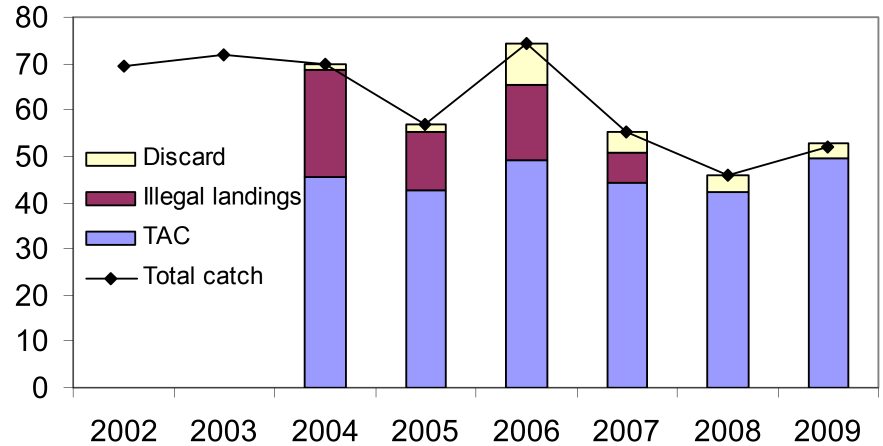


Figure 5.1. Total catch of the Eastern Baltic cod, broken down to landings corresponding to TAC, discards and illegal landings (data from ICES WGBFAS 2010).

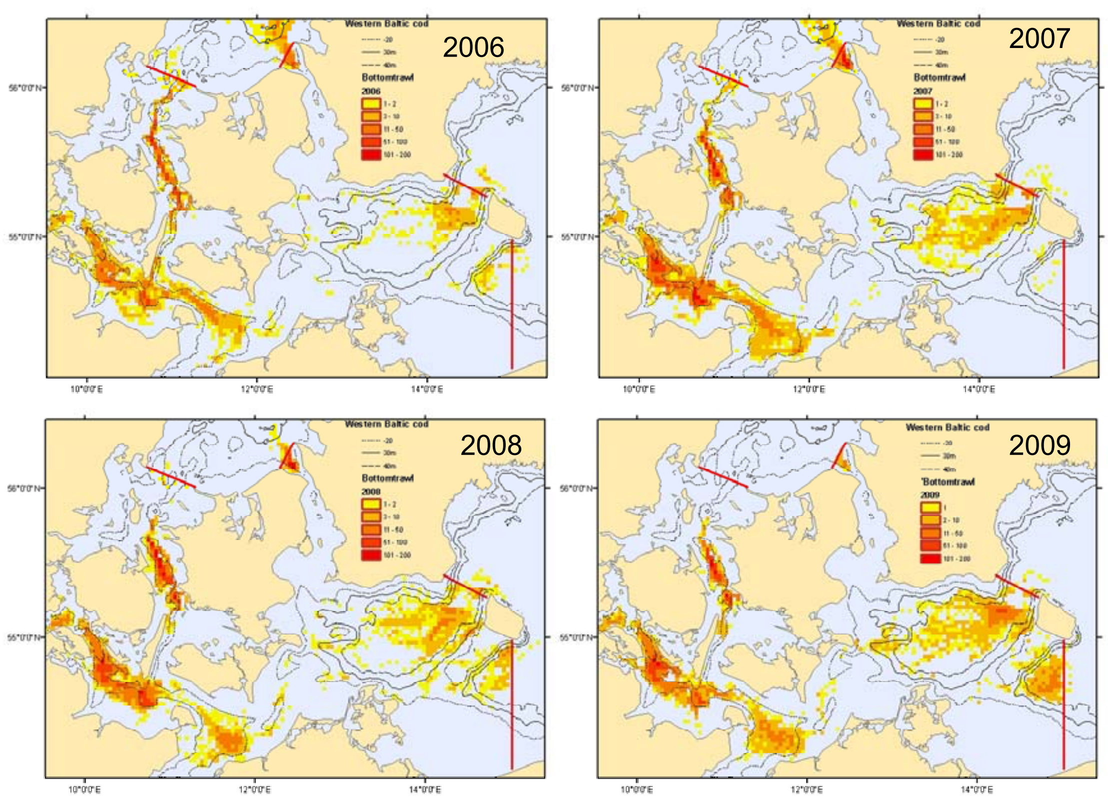


Figure 5.2. VMS data for 2006-2009 from the Danish bottom trawlers catching more than 25% cod and operating with a speed between 2-4 knots, where landings has been reported to be in the Western Baltic Sea.

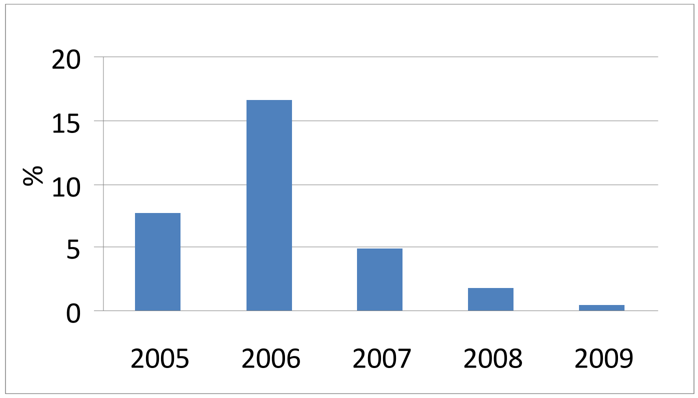


Figure 5.3. The percentage of VMS data from the Danish bottom trawlers catching more than 25% cod and fishing with a speed between 2-4 knots, which have been outside the Western Baltic while landings has been reported to be in the Western Baltic.

The CFCA have been coordinating control efforts in the Baltic. The Joint Deployment Plan (JDP) for cod fisheries in the Baltic Sea started in 2007 and has organised the pooling of human and material control resources (inspectors, control vessels, aircraft, etc), from the eight EU coastal Member States. The CFCA coordinates the implementation of this JDP, in tight cooperation with the Member States, promoting:

- A more effective and uniform control of fishing activities.
- Level playing field for the fishing industry
- Increased transparency on control operations
- Cost effective use of national control resources.

In this context, MS have been cooperating in joint campaigns with joint inspections at sea, and several training sessions and workshops were organized in the area. As a result of these activities, CFCA now observe that there is a better basis for a common risk analysis in the area, and harmonization of control and inspection procedures and a better match between the catch opportunities and fishing effort deployed.

6. ENVIRONMENTAL EFFECTS OF THE PLAN

6.1. Evaluation of the effects of the management plan on the fishery

6.1.1. Trends in Fishing Effort Allocation, Landings Composition, and Discard Behavior for national fleets and fisheries in the Baltic Sea

Trends in international fishing effort and effort allocation, landings composition as well as changes in discards of cod in the Eastern and Western Baltic Sea were evaluated with focus on cod fisheries. This is in order to separate possible changes over the period before and after implementation of the long term Baltic cod management plan. The results of the evaluation are presented in Annex C.

Effort and species composition of landings

During the period 2004-2009 there has been a general decline in effort for the most important fleets and fisheries catching cod both in both the Eastern and Western Baltic Sea areas, e.g. for the large-meshed demersal otter board single-trawls and large-meshed cod gillnets. This trend is rather general, and no specific tendencies and trends in effort for the different national fleets and fisheries can be detected directly associated with the implementation of the long term Baltic cod management plan.

The main fishery in terms of landed weight is conducted with large-meshed demersal otterboard single-trawls and large-meshed cod gillnets. In more recent years, longline and hook fisheries have also become more prevalent.

For the period 2004-2009 there are no detectable trends or tendencies in landing compositions associated with the implementation of the long term cod management plan in the Danish, German and Swedish catch compositions by Data Collection Framework (DCF) metier from the Eastern and Western Baltic Sea, respectively.

Effort reductions may not have flowed directly as anticipated by the plan for a number of reasons; partly because smallest vessels are probably not be effected by the rules at all; partly because under the days-at-sea regulation some vessels may fish for a greater proportion of the day; and partly because the regulation is based on days not kWdays there is a possibility for more powerful vessels to move out of the North Sea and IIIa into the Baltic without additional restriction, (while conversely lower powered vessels may replace these in the North Sea with the same kWdays this obtaining increased days).

Cod discards

According to the discard estimates used in the ICES assessment, discards of the Eastern Baltic cod at age 1 have been substantially reduced since 2004. The proportion of cod catch discarded at age 3 has been about 15% higher in 2006-2009 compared to 2000-2005. The total numbers of cod discarded in the Western Baltic have been substantially lower in recent three years compared to earlier period, which is likely due to reduced overall level of catch of younger age-groups due to a lack of stronger recruitment in recent years. The proportion of catch of Western Baltic cod that has been discarded does not show major trends since 2000.

Increased cod abundance in the Eastern Baltic in recent years could potentially give incentives for high-grading. Potential occurrence of high-grading has been analysed only based on Danish data. First length-distribution of cod discards, from trips with an observer onboard, shows no indication of high-grading, as discards consisted of cod below minimum landing size (38 cm) both in the Eastern and Western Baltic. Secondly, cod landings structure (by sorting categories) from trips with an observer onboard was compared with size structure of cod landings from trips without an observer onboard. The results show that size structure of cod landings both in the Eastern and Western Baltic was similar regardless of whether observers were onboard or not. Thus suggesting that high-grading has not been an issue in the Danish cod fisheries in the Baltic in recent years (analyses where based on data for 2009). There are however, recent reports from observers of other fisheries that high-grading occurred even after the high-grading ban was introduced in January 2010.

6.1.2 Changes in technical measures

During the period of the development and enforcement of the multi-annual plan for both cod stocks, a number of additional technical measures have been applied and modified over time. This holds especially for the description of what constitutes legal gear (construction, mesh opening, definition of an escape window), the minimum landing size of cod (increased from 35 cm to 38 cm by Jan. 2003) and the definitions of closures, temporal and spatial, to protect spawners. Since the plan was implemented, two different codends have been legal, the BACOMA and the T90 trawl. As of 1 Jan. 2010 in the Western Baltic and as of 01 Mar. 2010 in the Eastern Baltic, minimum mesh opening was increased in the BACOMA escape window and the T90 codend from 110 mm to 120 mm (Council Reg. 1266/2009 amended by 686/2010).

Annex D: on the changes in gear and gear selectivity provides details of all most legislative changes 2000-2011.

A study conducted this year evaluated the influence of the changes of technical measures for gear targeting cod in the Baltic on the overall selectivity. For each of the 8 different nets (combinations of construction and mesh opening), the level of discard which would have been induced when using this net in January 2010 was simulated. This was done using the length frequency distributions of cod in SD 24 for the Western fishery and SD 25 for the Eastern fishery, as obtained from trawl surveys. Selection curves were obtained by extensive sea trials conducted until early 2010. The results demonstrate that selectivity of gear has significantly improved in the last 10 years (text table below) in both areas. However, for the most recent gear change in 2010, there was no detectable difference in estimated discard rates when using the Bacoma trawl, there was even an increase in discard rates in SD 24. This might be caused by the dual selectivity of the Bacoma trawl, where the mesh opening of the bigger part of the codend has remained at 105 mm and only the escape window has an increased mesh opening.

cod end	SD24	SD26
T0 120mm	60.3%	37.9%
T0 130mm	54.4%	32.3%
Exit window type 1	28.9%	13.5%
BACOMA 120mm (2002)	21.1%	8.2%
BACOMA 110mm	28.5%	13.2%
BACOMA 120mm (2010)	30.7%	12.9%
T90 110mm	17.9%	7.4%
T90 120mm	12.8%	4.3%

These results indicate that a simple increase in mesh opening may not necessarily improve selectivity. In addition, other means to reduce discards might be more effective, such as reducing or abandoning the minimum landing size along with the highgrading ban already implemented in Baltic cod fisheries since Jan. 2010. Also, the creation of incentives for fishers to improve selectivity by means of a variety of measures, including choice of fishing area or season, or rigging of the net, might be a more effective approach than the attempt to define legal gear in ever-increasing detail. It should also be highlighted that the present definition of gears tries to address selectivity for the main target species, cod, but not those of bycatch such as flatfish. Considering that this fishery is a mixed fishery in many areas, there is clearly scope for improvements.

6.1.3 Unaccounted (or poorly defined) removals from the stock

The major problem with regard to unaccounted removals of Baltic cod was the illegal overfishing in the Eastern Baltic. This has amounted to 35-45% in addition to reported landings until 2008. Since then, much improved compliance has been recorded and illegal overfishing was reduced to less than 10% in recent years. The reasons for this change are discussed in Section 5. Information on illegal landings were included in the ICES assessments so they were not strictly unaccounted removals. However, large uncertainties existed on the actual amounts and composition of these additional catches, as no sampling of these was possible and thus only the composition of legal sampled commercial catch could be extrapolated.

A second source of poorly defined mortality comes from discards. These can be highly variable, and sampling of discards is poor in both stocks. Management tried to reduce the amount of discards by means of technical measures (see Section 6.1.2), however more fundamental approaches to address discards have only been considered since 2009 (see the Baltic Fisheries Director's initiative to eradicate discards 2010). One form of discarding, the high-grading or discarding of fish that could be legally landed, is prohibited also in the EU part of the Baltic since Jan. 2010 (Art. 7 of Council Reg. 1226/2009).

According to the discard estimates used in the ICES assessment, discards of the Eastern Baltic cod at age 1 have been substantially reduced since 2004. The proportion of catch discarded at age 3 is indicated to have been about 15% higher in 2006-2009 compared to 2000-2005 (Annex D). The proportion of catch of Western Baltic cod that has been discarded does not show major trends since 2000. The total numbers of cod discarded in the Western Baltic have been substantially lower in recent three years compared to earlier period, but this is partly due to reduced catch and the lack of stronger recruitment.

Catches by recreational fishers are at present not included in the ICES assessment. EU pilot studies conducted between 2004 and 2007 have demonstrated that those catches can amount to a significant fraction of the total cod removals (STECF SGRN 07-02 report on pilot studies 2007). In Germany, recreational fishers (Western Baltic) catch peaked in 2005 at almost 50% of the commercial fisheries' catch from the same area. The collection of data on recreational fisheries from stocks which are under a recovery plan is now mandatory. However, the structure of recreational fishing is so diverse among Baltic States that methods to obtain reliable data had first to be harmonised. ICES has conducted a workshop (WKSMRF 2009) and created a planning group (PGRFS 2010) to facilitate this harmonisation. Recent data suggest that also in Danish waters of the Western Baltic recreational fishers catch is significant compared to the commercial catch (roughly 5-10%, Sparrevohn and Storr-Paulsen, DTU Aqua report no. 217-2010). Apart from the absolute amount, the variability of recreational fisher's catch of cod likely causes uncertainties in the assessment of the stocks. Recreational fisher's catches should therefore continue to be monitored and should be included in the assessment as soon as possible. It is expected that, at least for the Western Baltic, this can be achieved within the next 4-5 years. If included, it seems likely that the estimated stock will appear more productive than without these additional removals. Annex E on recreational fishing provides an update on recent recreational fisher's catches and the structure of this fishery in Germany.

6.2. Evaluation of the effects of the management plan on the stock

6.2.1. Cod in Sub-divisions 25-32 (Eastern Baltic cod)

Fishing mortality of the Eastern Baltic cod has declined since 2005 and reached the level below the management target (0.3) in 2008. Fishing mortality for 2009 was estimated at a similar level as for 2008. Spawning stock biomass has simultaneously increased from less than 70 kt in 2005 to 220 kt in 2009 and is predicted to be close to 300 kt in 2010 (Fig. 6.1).

Recruitment (age 2) in 2005-2009 has been higher than in the previous five-year period; especially the 2006 and 2007 year-classes (age 2 in 2008 and 2009) are the strongest since 1987.

Total catch of the Eastern Baltic cod in 2007-2009 was 20-30% lower compared to the level in previous years (2002-2006). Major part of this reduction in total catch was due to improved compliance with TAC (Fig. 6.1). TAC was reduced by 10% for 2007 and by a further 5 % for 2008, and increased by 15% for 2009 and again for 2010.

The observed decline in fishing mortality since 2005 was due to a combination of reduced catch and increased recruitment, which equally contributed to the reduction in F. Additionally, a change in selection at age which has taken place in recent years contributed to the overall reduction in fishing mortality (Fig 6.2). The observed increase in spawning stock biomass was mainly driven by increased recruitment, though the reduction in catch contributed to the increase in SSB as well. Specifics of these analyses are described in Annex F.

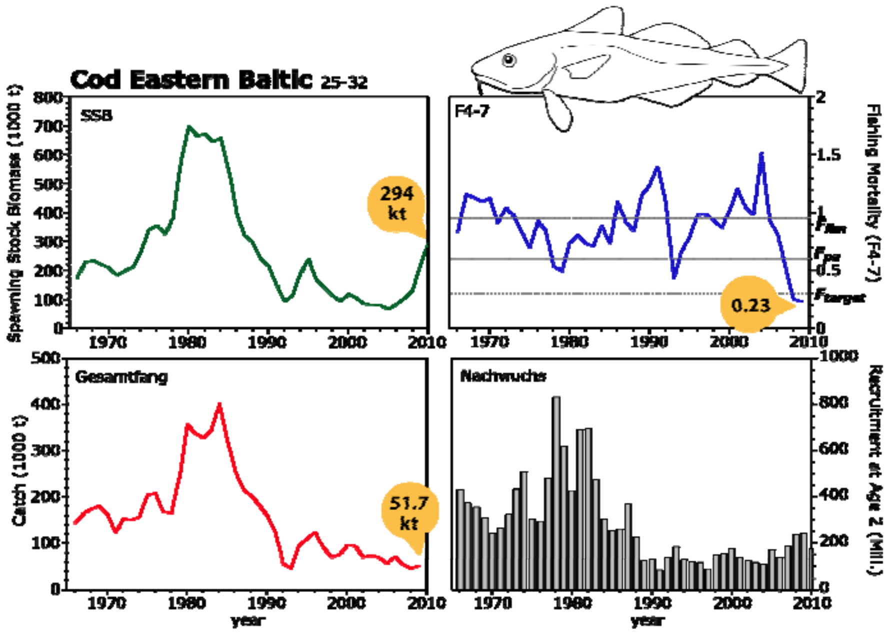


Figure 6.1. Cod in SD 25-32.Summary of stock assessment. The latest estimates of recruitment and spawning stock biomass are for 2010, the latest estimate for fishing mortality and catch is for 2009 (ICES 2010, modified).

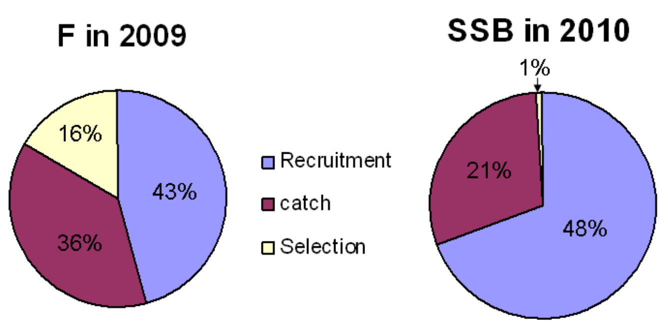


Figure 6.2. Relative contribution of increased recruitment, reduction in catch and change in selection at age to the observed decline in fishing mortality and increase in spawning stock biomass of Eastern Baltic cod. The numbers show the percentages how much fishing mortality in 2009 would have been higher and SSB in 2010 lower if the observed change in a given parameter (shown in the legend) would not have taken place.

6.2.2. Cod in Sub-divisions 22-24 (Western Baltic cod)

Fishing mortality of the Western Baltic cod declined from an average level of around 1.1 in 2000-2005 to 0.79 in 2006. In 2006-2009, fishing mortality has remained relatively stable and is estimated at 0.72 for 2009. Spawning stock biomass of Western Baltic cod has fluctuated at around 25 kt during 2000s, without clear trends (Fig. 6.3).

Recruitment of Western Baltic cod has in recent years been weak. The last stronger year-class was observed in 2003 (age 1 in 2004). Recruitments (age 1) in 2005-2008 have been among the weakest in the time-series; the 2008 year-class is estimated to be moderate (Fig. 6.3). Individual weight of cod older than age 4 in the catch in SD 24 has been up to 60% lower in 2007-2009 compared to earlier years, whereas no change in mean weight at age has been detected in SD 22 (Fig. 6.4). The pronounced decline in mean weight at age in the catch implies that higher numbers of cod have to be caught to obtain a given amount of yield (in weight), which increases fishing mortality. The stable fishing mortality estimated for 2006-2009 indicates that if the decline in mean weight at age would not have occurred, fishing mortality might have declined in recent years.

An additional observation with influence on the estimation of the SSB is that the maturity ogive for Western Baltic cod has been reduced in the last five years – in 2008, only half of the cod older than 7 years contributed to spawning (Fig. 6.5). This high fraction of skipped spawning is unusual for cod stocks and could be caused by limited food availability or by displacement of summer spawners into an inappropriate area. Data is not yet worked up separately for SD 22 and SD24; this could provide further insight into the causes. Maturity ogives are not monitored annually in the Eastern stock so such a development can neither be verified nor refuted in the East. (ICES WGBFAS 2010).

Catches of Western Baltic cod have been relatively stable, close to 26 kt in 2002-2007. In 2008-2009, total catch was reduced about 20% in both years, in relation to reduction in TAC (Fig. 6.3). The TAC was first set in accordance to the management plan for 2009. This resulted in a 15% reduction in TAC which also corresponded to almost 10% reduction in fishing mortality. In the assessment in 2008, status quo fishing mortality (average for 2005-2007, unscaled as no trend was perceived) was 0.96. Later assessments resulted in a lower estimate of fishing mortality for the same years (0.86), due to generally overestimating fishing mortality in the final year of the assessment for Western Baltic cod (retrospective bias in the assessment). Consequently, the level of fishing mortality that in 2008 was intended to be reached in 2009 (0.87) by reducing the TAC by 15% was, according to the latest assessment, actually already the level in 2005-2007. Due to a retrospective bias in this assessment, it is at present not possible to evaluate the effect of implementation of MP on fishing mortality in 2009. The current estimate of F for 2009 is 4% lower than the estimate for 2008. However, the estimate for 2009 is at present uncertain and will likely change when an updated assessment will be conducted in 2011.

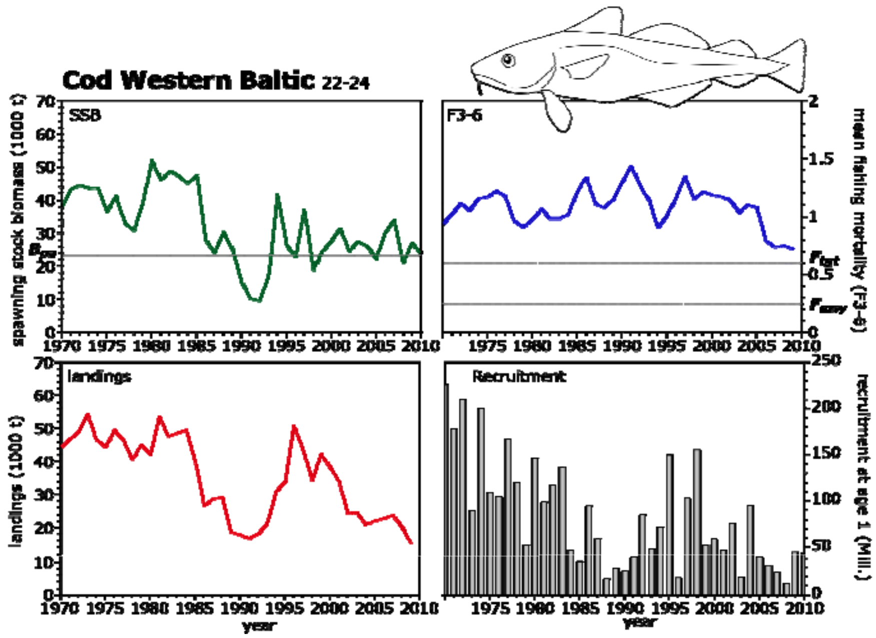


Figure 6.3 Cod in Subdivision 22-24. Summary of stock assessment, F mortalities and SSB have uncertainties plotted (ICES 2010, modified).

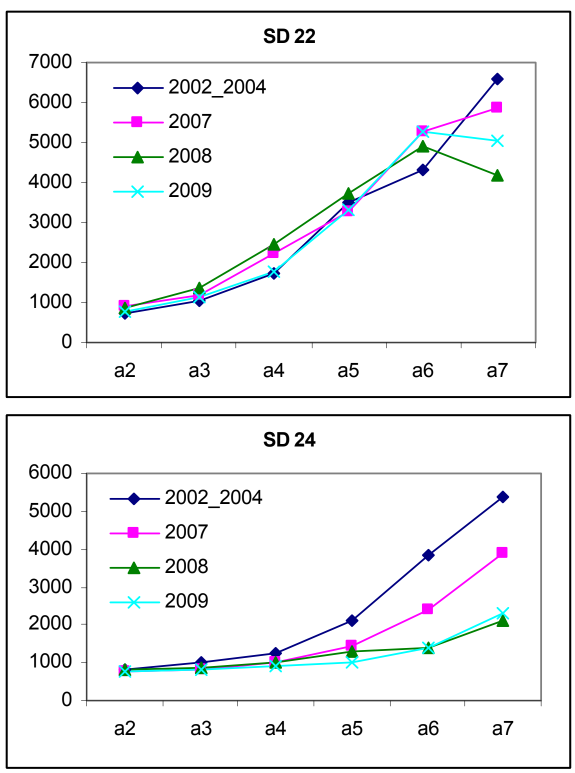


Figure 6.4 Changes in mean weight at age in catch of cod in Subdivisions 22 and 24 .

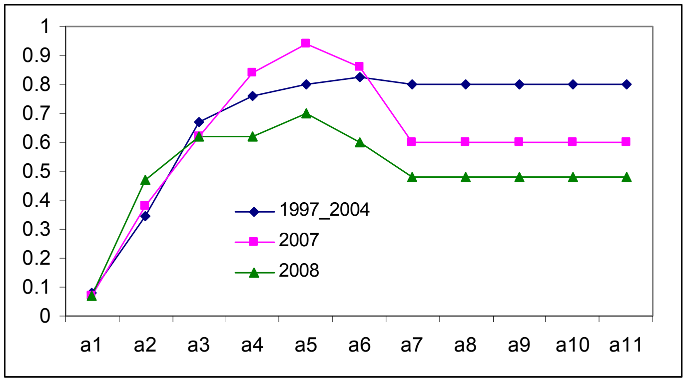


Figure 6.5. Change in the proportion of spawners of Western Baltic cod (SD 22-24) by age.

Distribution, migration and mixing of the two cod stocks

It is well known that Baltic cod conducts wide migrations from feeding to spawning grounds. Also, there are indications of some mixing between the two stocks (see annex: G on the distribution of cod in the Baltic). Assignment of fish in commercial catch to stock is at present not possible. The present perception is that a fraction of juveniles spawned in the West are passively drifted to the East. If these fish then return for spawning, i.e. keeping their spawning site fidelity, or contribute to the Eastern stock is unknown. Also, mixing of adults occurs in the bordering areas SD 24 and SD 25. The fraction of summer spawner type cod in SD 24 has increased, although again it has not been detected that these fish then spawn in SD 24. An increasing influence of Eastern cod on Western cod can be expected when one stock is increasing rapidly while the other remains rather constant at a low level. A likely effect of this is to mask the effect of fishing on the smaller stock, making it more vulnerable. In this situation it is necessary to afford additional protection to such components (SGHERWAY 2010). Simulations (Annex G) have been carried out with a variety of age dependent emigration and immigration rates (see Annex G pt3) typically 10% (from West to the East) and an emigration rate of 3% (East to the west). The impact on management of these levels of mixing are considered to be negligible in the context of reaching the area based targets of the management plan, however, mixing may mask the impact on the underlying stock structure, and may be important.

In recent years, the fishery in SD 24 in the Western Baltic has become more important as the major part of cod catches in the Western Baltic is currently taken in SD 24. At the same time, the higher stock in the Eastern Baltic might have caused an increase in the proportion of Eastern Baltic cod in SD 24. This is supported by increased fishing intensity (indicated by VMS data) in the area south of Bornholm (close to the border between SD 24 and 25). In 2009, 30% of the Danish fishing effort in SD 24 was allocated to the ICES statistical square 38G4, which corresponds to the area south of Bornholm (see Fig. 5.2). The proportion of Danish cod landings in SD 22-24, taken in this statistical square increased from app. 5% in 1995-2004 to 20% in 2009.

The increased proportion of cod in the Western Baltic belonging to the Eastern stock may bias the assessments of Western Baltic cod. If this results in different mortality rates for the two stock components in the western Baltic, the estimates of F from the assessment may not be representative for the "true" Western Baltic cod stock, which complicates the evaluation of the management plan effects on Western Baltic cod.

Taken together, the likely movement of eastern Baltic cod into the western area, the recent low recruitment, and the low weights at age in Western Baltic cod suggests that this stock is currently under some biological stress. Under these circumstances maintaining a higher fishing pressure on western cod might not be advisable (see also MSY considerations below).

Currently we are unable to draw conclusion and to select the most effect measure to protect both stocks under these circumstances. Further study is required to evaluate the most effect management measures.

In addition to mixing there is some information on stability of distribution at age. Analyses conducted in the recent past indicate that there are no clearly defined areas constant between years where high concentrations of juveniles can be found. This makes it unlikely that juveniles could be protected by measures such as closures of fixed areas. Real-time closures however might be a suitable alternative to improve recruitment into the fishable stock.

6.2.2. MSY considerations

For Eastern Baltic cod, ICES has suggested Fmsy at 0.3, obtained from stochastic simulations (ICES WGBFAS 2010). This estimate is close to Fmax from yield per recruit analyses and is in line with the target F of the multi-annual management plan.

For Western Baltic cod, Fmax from yield per recruit analyses corresponds to 0.24. Stochastic simulations were conducted (Annex H) to estimate Fmsy assuming different stock-recruitment relationships. The analyses resulted in Fmsy estimates between 0.21 and 0.55, depending on the stock-recruitment relationship used. As historically the stock has been exploited at Fs near 1 for most of the time series (Figure 6.2) exploiting at such different harvest rates implies correspondingly high biomasses, SSB between 300 -1200 kt, exceeding ten to forty times the level of current SSB. However, the analyses did not take into account density dependent changes in growth and mortality at high stock abundance.

Investigation of the stability of Fmax suggests that the value of 0.24 is not particularly sensitive to changes in cannibalism at young ages and weights at age. Currently the best available proxy for Fmsy is Fmax. If the stock recovers to higher biomasses than those previously observed it will be necessary to re-evaluate an F_{msy} target.

6.2.3. Achievement of targets Medium term prediction to 2015 and 2020

Management Strategy Evaluation (MSE) and simulation of consequences, robustness and sensitivity of the Baltic cod multi-annual management plan to achieve stock recovery within the medium term for both the Western and Eastern Baltic cod stocks are given in Annex I.

The management plan evaluations for the Eastern Baltic cod is based on results given in the scientific peer reviewed papers Bastardie et al. (2010a,b) using input data from the ICES WGBFAS 2008 assessment which has been updated in the WKROUND 2009 benchmark assessment (Bastardie et al., 2010a). Actual stock conditions have changed compared to the evaluated conditions for the Eastern Baltic cod stock as the recruitment has been higher in recent years compared the low recruitment level used in the presented evaluations. This means that the targets of the management plan have been achieved faster than predicted under a low recruitment scenario for Eastern Baltic cod. The presented evaluation results for this stock show, consequently, that the management plan targets would also have been reached with high likelihood in the medium term if there had only been consistent low recruitment in this period. The conclusions from these studies are considered acceptable for Eastern Baltic cod.

For the Western Baltic cod the management plan evaluation has also been done according to the methods and evaluations given in Bastardie et al. (2010a), but is in present context up-dated with input data and results from the ICES WGBFAS 2010 assessment. However the current ICES assessment is now based on a different model, so the starting numbers are slightly different.

The full details of the methods and the assumptions made about the logic of the implementation are given in Annex I (see also the design issues in Section 4)

The MSE scenarios evaluated in Annex I cover efficiency of the management plan according to both the F targets for the plans and also estimated values of Fmsy (See Section 6.2.2). In addition Annex I also includes evaluations that involve different year on year TAC constraints.

In general, it should be emphasized that the evaluation results and the chance of success of the 2008 management plan is dependent on a number of pre-conditions and assumptions on sources of uncertainties and their magnitudes. First of all, the targets of the plan should reflect the stock dynamics.

For Eastern Baltic cod the plan is robust to assumptions of either low or high recruitment and the plan target and Fmsy target are generally similar (see Section 6.2.2).

As shown in Section 6.2.2 the F-target of 0.6 for the Western Baltic cod is probably too high. Another condition for Western stock is the initial population number at age used from the assessment and the level of fishing mortality assessed at the start of the period coming from the ICES assessment model, i.e. model error according to the model used. The 2008 management plan has been shown to be very sensitive to the initial assessment providing initial F and N estimates (assessment errors) (Bastardie et al., 2010a). There is a risk of initiating the gradual F reduction procedure with a high targeted F (if the initial F is high) while the stock is presently overexploited (low SSB from high F). However, for the Western stock it should be noted that the initial population Ns and F are similar between the XSA and SAM assessment models (ICES WGBFAS, 2010).

The biological parameters are assumed to be constant on the long term basis in the MSE. It is apparent that the strongest factor controlling the magnitude of the success of the management plan is the level of recruitment (Bastardie et al., 2010a). The projections have assumed that lower levels comparable with the period 1986 onwards will continue. This low recruitment regime tested did not prevent stock recovery. However, in the most recent years cod recruitment in the Western Baltic Sea has been below the average recruitment even in the low recruitment regime during 1986-2007. There are also indications of very recent changes in mean weight at age and maturity compared to the averages used for 2005-2007 in the simulations. Under these circumstances it is possible that simulated recruitment is too optimistic and in any case these very recent biological changes add some uncertainty to the projections for Western Baltic cod which are not included within the variability simulated.

In general, the plan has been shown to be robust against uncertain data and various degrees of errors in the perception of the true stock dynamics (observation errors), and model settings. Changes to these did not change the trends but could delay the period before the targets are reached. It is a condition that the observation and assessment errors added or generated in the management procedure remain with the same order of magnitude as that tested. Finally, the effort reduction in the intermediate year needs to be fully complied with and the exploitation pattern should remain constant.

For Eastern Baltic cod, simulations demonstrate that once the management target has been reached, F may reduce further due to the TAC constraint and in the medium term exploitation at Fmsy is achievable.

For the Western Baltic cod the results of the MSE with up-dated data indicate that the current management target of F=0.6 under the long term management plan will be achieved with more than 50 % probability (median) by 2015 in the medium term prediction under an average low recruitment situation for the Western Baltic area (recruitment period included is 1986-2007). A potential management target of F=0.24 will also be achieved with more than 50% probability within the medium term, but with 1 year delay, i.e. by 2016. This is the case also in a situation where there is 10 % mis-reporting on landings, i.e. with an implementation error of 0.1. However, it should in this context be emphasized that the simulated projections are based on assumptions on constant, average biological conditions, e.g. recruitment, for the Western Baltic cod in the projected period as discussed above as well as based on correct initial stock levels simulated (N and F). In the context of a potential change to target F for western Baltic cod, and the projections in Annex I it is perhaps worth noting that should recruitment follow the historic range, assumed interannual restrictions to TAC will result in attaining the lower target. However, if the recruitment is closer to the most recent years and mean weights remain low, then additional protection of the Western Baltic cod stock other than obtained from the measures in the management plan may be necessary.

6.3. Evaluation of the effects of the management plan on the ecosystem.

No analysis is available.

7. SOCIAL AND ECONOMIC EFFECTS OF THE PLAN

7.1. Selection of relevant fleet segments:

Data were taken from the 2010 AER data call for years 2002-2008. Data were extracted for all fleet segments that had catches of cod in FAO area 27.3. For some fleet segments, data on transversal variables (effort and landings) were provided in a regional aggregation which did not exactly match the Baltic region. However, this could be adjusted, e.g. excluding data from FAO area 27.3. However, this was not possible for some fleets because the area basis submitted in the data call was insufficient to allow this. In some cases the fleets could be clearly identified as 'Baltic'(area 27.3b,c,d) and 'non-Baltic'(area 27.3a) based on a knowledge of fleet structure, in others, mostly Danish fleets the fleet segments were known to have vessels operating inside (27.3b,b,d) and outside area (27.3a and 27.4) but no effort data was available to split the activities. Summary of the economic data is given in Annex J.

For the economic analysis, fleet segments, within which the value of Baltic cod landings contributed to more than 20% of the total value of landings during 2002 - 2009 period have been selected for further analysis. This threshold was applied to fleet segments (as defined in DCR and DCF) as a whole. There was no individual vessels information available for precise evaluation of cod dependent vessels. Three of these fleets with high proportions of landed value of Baltic cod were then excluded as they has poor data and contributed little to the overall catch of Baltic cod. This approach led to the selection of 16 fleet segments, fishing in the Baltic accounting for about 88% of cod landed by all fleet segments for which data have been submitted (Fig. 7.1).

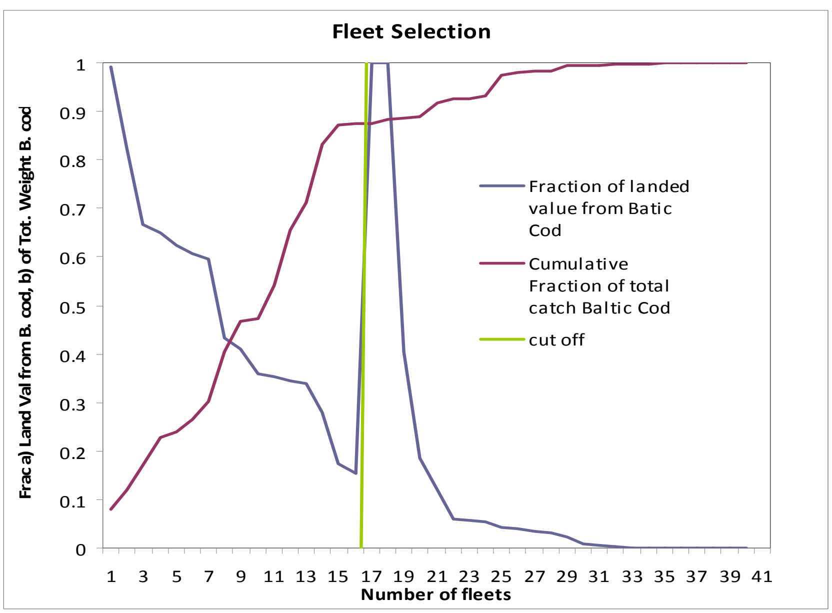


Figure 7.1. Selection of fishing fleets for the analysis, showing the fraction of the value of Baltic cod by fleet, for selected fleets (left) and unselected fleets (right). The cut of line and the cumulative fraction of Baltic cod included in the selected (88%) and unselected (12%) fleets.

The dependency of selected fishing fleets to the value of cod landings was different across years. The percentage of the value of cod landings in respect to the total landings is presented in Annex J

Due to lack of area allocation to effort data, no Danish fleet segments could be analysed. For all other EU MS involved in Baltic cod fisheries, data have been made available. One Estonian fleet segment was identified as taking most of the Estonian cod quota but this fleet segment did exceeded the 20% threshold and it was decided that its economic dependency would be small so it was excluded along with the other fleets with low Baltic cod dependency..

For 2002-2003, data from new MS are incomplete as there was no obligation to collect it prior the accession, so the coverage that period is only about 34% (see Table 7.2). The total volume of cod catches covered by the selected fleets was 54-58% of total cod catches in 2004-2009 recorded in the ICES Advice.

Table. 7.1: Shares of total Baltic cod catches covered by selected fleet segments

Country	2002	2003	2004	2005	2006	2007	2008	2009
Denmark	0%	0%	0%	0%	0%	0%	0%	0%
Estonia	0%	0%	0%	0%	0%	0%	0%	0%
Finland	16%	37%	40%	35%	11%	8%	19%	
Germany	78%	78%	82%	76%	74%	80%	74%	69%
Latvia	99%	124%	97%	99%	94%	93%	96%	98%
Lithuania	0%	0%	116%	80%	74%	98%	79%	83%
Poland	0%	0%	88%	90%	90%	82%	91%	91%
Sweden	90%	95%	94%	103%	99%	94%	96%	96%
Total Baltic (incl. Russia)	34%	34%	58%	56%	55%	55%	54%	57%

In the Baltic fishery cod is mostly targeted by demersal trawls or fixed nets. Therefore, most of the selected fleet segments have these as dominant gear. The segments with pelagic trawls as dominant gear target cod with demersal gear, but over the year their effort is dominated by pelagic gear.

7.2. Data issues/reliability:

As anticipated at the scoping meeting no cost data were available for 2009 by the time of the meeting; moreover, some effort data were missing for 2009. Neither the number of vessels achieving more than 20% of revenue through cod nor a distinction of catches by ICES area were provided for analysis, as proposed in SGMOS 1006a.

Effort data are not equally meaningful over all gear classes. While data from mobile gear fisheries are quite indicative, data from static gear are to some extent arbitrary and not comparable. One unit of effort reflects quite different units in terms of catchability between the two groups.

Cost data are in many cases afflicted with higher uncertainty. Moreover, the calculation of some cost variables has changed with the transition from data collection under Commission Regulation (EC) No. 1639/2001 to collection under Commission Decision (EC) No. 949/2008, impeding the comparability within time series (e.g. calculation of crew costs, other income, etc.).

7.3. Estimation of missing variables for 2009

Polish effort data for 2009 were missing in the datasets produced for the meeting. Therefore they were estimated using the catch per day and GT from previous years and the catch reported for 2009. When the result exceeded the maximum number of days at sea per vessel, the effort was assumed as that maximum.

The values of landings were the only economic variables available for analysis which could be specifically assigned to Baltic cod fishery. Thus estimates of income from Baltic cod fishery could be regarded as acceptable. Cost variables also had to be estimated for 2009. Crew wages were estimated as proportion of value of landings (average in 2006-2008). Non-variable costs were estimated proportional to the number of vessels. Employment and all other cost variables were estimated proportional to effort observed in previous years. The fuel cost were amended using a factor of 0.7, derived from price indices on fuel oil to address price changes from 2008 to 2009.

7.4. Discussion of economic evaluation

Stakeholder opinion had been requested during the preparatory meeting and has been obtained during the evaluation meeting in order to focus on most relevant aspects. According to this, any potential economic impact of the Baltic cod management plan since its implementation has been superimposed by external effects, in the first place the drop in sales prices. The decrease in price has been partly attributed to campaigns which criticised cod for being unsustainably exploited, while substitutes (e.g. pangasius) were being declared sustainable.

It has been stated that a major benefit from the cod management plan derives from decreased uncertainty with respect to quota fluctuations. Potential consequences are a higher willingness amongst fishermen to invest in their vessels and a less restrictive loan policy at the money market. These effects might only become evident in the available economic data after a longer time period.

As there was no evidence for particular analyses, the available data have been generically processed and scrutinised for relevance and potential trends. The results of the calculation and basic economic data collected are presented in Annex J.

A tendency towards decrease in vessel numbers can be observed, which is consistent with common observation and cannot be assigned specifically to the cod management plan. A strong decrease in number of vessels has occurred in Poland due to a decommissioning scheme.

Over the years, the overall contribution of cod to total revenues has decreased. This is only partly due to decreasing prices, as there is the same tendency for landings, though to a lesser extent. A reliable interpretation of trends of other variables is highly uncertain for a number of reasons mentioned previously.

A separate consideration of the economic effects of Western and Eastern stocks could not be performed. Different trends in TACs for Eastern and Western cod stocks might have influenced fleets differently. As cost and effort data are only available for fleet segments as a whole, these aggregate data cannot be clearly assigned to activities targeting cod. As an auxiliary approach, the ratio of revenues of cod to total revenues has been applied to estimate the fractions of cost related to cod. However, these data have appeared too arbitrary and are therefore not further explored.

For the calculation of cod dependency ratios, the impact of fish prices has been reduced using constant cod and other fish species prices. As a result, costs, attributed to the cod fishing been calculated and economic indicators (GCF, GVA and profit) been calculated. The results showed quite good profitability of cod fishing during last few years, since the scrapping schemes have been introduced. The profitability before the implementation of restriction rules (effort and TAC reduction starting 2005) was observed to be lower. However, this approach and results treated with caution and would benefit from more elaboration analysis.

7.5. Economic Outlook

The evaluation of economic aspects of the Baltic cod management plan has been performed on a fleet segment basis in accordance with DCF legislation (EC 949/2008). This has substantially limited the significance of the findings. Future evaluations should include attempts to focus on vessels affected by the measures or at least give an estimate of the size of the fraction of a fleet segment which is affected. Further effort might be spent on increasing consistency of time series by using more congruent data. The implementation of the DCF (EC 949/2008) facilitated better data in the long term but introduced inconsistencies in time series pre and post 2008. For instance, labour costs were split into crew costs and imputed value of unpaid labour. For the analysis, only crew costs were provided, leading to an artefact, a drop in wages from 2008 on.

The range of data potentially available would allow a broad range of potential analyses, e.g. on national or regional or fleet segment level. The time available during an evaluation meeting is not sufficient to run all these analyses. In order to focus on most relevant issues, some input from stakeholders might be requested more in advance and more structured as a prerequisite to perform a purposive economic analysis in the future.

8. THE ADDED VALUE OF THE MANAGEMENT PLAN

The first year in which the TACS were set under the management plan was 2009.

8.1. Eastern Baltic cod

The TAC of Eastern Baltic cod for 2009 was increased by 15% following the harvest control rules of the management plan. In the ICES advice for 2009, all scenarios resulting in fishing mortality at or below 0.6 (Fpa) were considered consistent with precautionary approach, in contrast to earlier years when fishery at any level was considered to be non-precautionary. This change was caused by the exclusion of precautionary biomass reference points in 2008 (to account for an apparent regime shift), which left precautionary F reference points as the only guide to give advice. A fishing mortality at 0.6 in 2009 would have corresponded to a 138% increase in TAC, giving a 23 % lower SSB in 2010 than the one corresponding to the option following under the management plan. Thus, the harvest control rules of the management plan (with lower target F and 15% limit for inter-annual changes in TAC) currently has allowed the stock to accumulate larger biomass than would have been the case under previous precautionary approach. Management plan is thereby facilitating further rebuilding of the Eastern Baltic cod stock. To allow this TACs have been lower than would have been the case without the plan.

8.2. Western Baltic cod

There is no Fpa reference point and as biomass is currently around Bpa for Western Baltic cod, it is not possible to estimate what would have been the target value without long-term plan. It seems unlikely that F would have been reduced faster in the absence of the plan. It might be expected that the TACs and stock SSB would have been similar with or without the plan.

Economic analysis cannot separate the results between the stocks or management areas but indicate that most fleet segments that have been evaluated have remained profitable.

9. PERFORMANCE EVALUATION OF THE PLAN

9.1. Effectiveness

9.1.1. Eastern Baltic cod

The management plan has in general been effective for the eastern Baltic stock. Recruitment has been higher in recent years compared to the past 10 years average. Since 2007 the compliance to management rules has been increased resulting in reduced catch and reduced F. From 2009 onwards in the absence of the plan higher catches than those allowed by the 15% constrain implemented according to the plan would have occurred. These restrained catches have contributed to the maintenance of lower F.

9.1.2. Western Baltic cod

In comparison to the eastern Baltic stock, the western Baltic stock has not shown any significant signs of recovery. The recent weak recruitment in combination with a reduced weight at age in the catch has resulted in the inability to reduce F as relatively larger numbers of individuals were required to provide the TAC. There is probably an additional effect related to increased compliance due to increases in removals from vessels that previously area misreported catches taken in the Kattegat into Western Baltic and are now taking those catches in the correct area.

9.2. Utility

There were no specific capacity objectives for the plan.

It appears that most of the fleets, for which we have detailed data, are in profit in 2009 thus from an economic perspective there in not over capacity. There is decrease in vessel numbers, which is consistent with the general aims of the plan to reduce effort but cannot be attributed directly to the plan. A strong decrease in number of vessels has occurred in Poland due to a decommissioning scheme. On the other hand, the data supplied shows that the number of Swedish demersal trawlers (operating in the Baltic) has increased considerably in 2008, though this could be an artefact of classification to fleet.

9.3. Efficiency (cost-effectiveness)

We have no information on the costs of enforcement, however, it seems clear that increased compliance has had an important positive effect for management of Eastern Baltic cod, and in the longer term it is anticipated that this will be beneficial for Western Baltic cod too.

9.4. Indicators

Generally the indicators have been useful for defining the economic results, however, some data shortages have meant that it has not been possible to calculate the full set of economic indicators for all countries.

9.5. Sustainability

Currently Eastern Baltic cod is being harvested a little below Fmsy and this is expected to be maintained provided the management plan is complied with. This is considered to be the case under the full range of recruitment regimes observed in the past. There is no reason to believe that this will not be maintained until 2015 and beyond under the plan.

Currently Western Baltic cod is being exploited above the F target of 0.6. Current estimate of Fmsy is F=0.24. The current management target is not compatible with this in the long term. Simulations suggest that the F target of 0.6 for Western Baltic cod will be reached by 2015 provided there is compliance with the plan.

9.6. Conclusions

For Eastern Baltic cod the plan can generally be regarded as effective.

For Western Baltic cod the plan is expected to be effective in reaching its target by 2015. However, in order to achieve exploitation at MSY the target for the plan should be revised. In order to ensure that a plan can be followed even under conditions of assessment errors such as retrospective revision, or some implementation error, targets should be based on a series of annually defined points not a series of changes relative only to the previous year.

9.7. Consideration for future work

There are a range of additional aspects that should be considered if there is to be a major revision of cod management in the Baltic, such as: timing of spawning closures, inclusion of recreational fisher's catch; and unresolved biological issues involving mixing and migration.

There are some concerns regarding the reduction in mean weight at age and fecundity for the older age groups in the Western Baltic stock. Future work or revisions to the plan should include continuity of these effects as a possible scenario along with developments returning to previously observed growth and recruitment.

Collection of economic or transversal data should be organised so that it can be attributed to the Baltic and within the Baltic to the Eastern and Western areas.

ANNEX A: FRAMEWORK FOR THE EVALUATION OF MANAGEMENT PLANS

A review of the practical implementation of the management plan considering the actions taken and measures implemented at the Member State level.

1. DESIGN ISSUES

• What issues relating to the design of the plan can be identified. eg. differences and/or ambiguity in interpretation of the requirements and/or provisions of the plan, or different levels of implementation of the plan. Analysis should be conducted at the Member State level.

• Has the plan been updated in the light of new information since first implementation e.g. have reference points been updated in line with more recent advice?

• In the case of multi-species plans, are the procedures for setting the TACs for the different species likely to lead to imbalances in the TAC levels for the stocks concerned.

• Has the potential overlap with other management plans been adequately addressed?

2. ENFORCEMENT AND COMPLIANCE

• What level of compliance has been achieved (using the background information provided above - analysis should be conducted at MS and EU level – i.e. MS implementation may differ and have differing outcomes)?

3. ENVIRONMENTAL EFFECTS OF THE PLAN

3.1. Evaluation of the effects of the management plan on the fishery

• What has been the fishery response to the management plan? The response strategies of the fleets include possible shifts to other stocks or species, to other gears or metiers and other behavioural issues.

• What measures of the management plan are considered to have influenced the fishery response. Measures of the management plan will include

• Catch and effort limitations – either through TAC or effort management

• Technical measures – eg. Closed areas, gear restrictions, etc.

• Control and enforcement measures – eg. Entry and exit rules, allocation rights, etc.

• Capacity management measures

3.2. Evaluation of the effects of the management plan on the stock

This section should be adapted to any particular plan and stock. The terms of reference proposed hereafter are drawing on the generic aspects of the evaluation.

a) Evaluating the stock response to the changes in the fisheries resulting from the plan - is the plan delivering its own internal objectives with respect to the stock?

• What changes in the stock dynamics can be identified and to what extent are these consistent with (or attributable to) changes in the fishery imposed by the management plan?

For example can reductions in fishing mortality be identified in instances where fishing effort has been reduced.

b) Evaluating whether the values of target and other reference points referred to in the plan are consistent with current knowledge and the objective of achieving MSY by 2015.

• Are the reference points in the plan still sensible given the latest information on stock status and dynamics?

• Is the plan likely to achieve MSY by 2015? If not, why?

• Is there a need to revise the measures in the plan to make it more effective in achieving the objectives?

• Is STECF able to propose options for a better plan to achieve stock – specific objectives?

3.3. Evaluation of the effects of the management plan on the ecosystem.

• What impacts of the management plan on the ecosystem can be identified? Ecosystem impacts might include changes in discarding practices, by-catch rates, habitat degradation, etc.

4. SOCIAL AND ECONOMIC EFFECTS OF THE PLAN

4.1. Data and Calculation of Indicators

• If there is no explicit socio-economic objective defined by the management plan the evaluation should be against the general socio-economic objectives as stated in the CFP.

• Characterise the social and economic state of the fleets exploiting the stock or stocks concerned using appropriate indicators, i.e. those proposed in the plan these below proposed by STECF in the April 2009 plenary report,.

- *Value of landings* ~ revenue from sale of fish.
- *Gross Cash flow* ~ income minus all operational costs (excluding capital costs).
- *Break even revenue* ~ long term break even revenue. The income (revenue) level at which economic profit is zero.
- *Gross Profit* ~ income minus all costs, including capital costs.
- *Gross Value added* ~ contribution to gross national product (GNP). Income minus all expenses except capital costs and crew cost.
- *Fleet size and composition*
- *Employment*

• The implementation and enforcement costs should be estimated, if possible in order to assess their cost effectiveness e.g do the benefits outweigh the cost of implementation and enforcement.

5. WHAT HAS BEEN THE ADDED VALUE OF THE MANAGEMENT PLAN

The question "What is likely to have happened if the management plan had not been put in place?" should be addressed. This should include a comparison between the current state of the stock and fisheries compared to the situation that is likely to have occurred had the management plan not been implemented. The scenario representing the absence of the plan will constitute the baseline scenario, as advised by the desk officer.

• With specific reference to the items identified in section 2, identify the benefits/losses to the fishery and to the stock that have resulted from the management plan. Analysis to be based on indicators of stock status and exploitation rate

• With specific reference to the items identified in section 3, identify the economic and social benefits/losses that have resulted from the management plan. Analysis to be based on suitable social and economic indicators.

6. PERFORMANCE EVALUATION OF THE PLAN

Based on the above analyses please answer the following questions.

NB: the judgment provided on the following questions could be qualitative (at this stage) where data are not available. Similarly if other effects are detected they can be considered.

Effectiveness

• What have been the immediate results and medium term impacts for the stock addressed by the management plan? Have the objectives of the plan been achieved?

• What have been the immediate results and medium term impacts of the management plan on the environment and the ecosystem, for example by-catch, discards, non-target species?

• Have there been any side effects resulting from the plan? (for example, changes in behaviour that affect other fisheries, or environmental consequences, changes in the market).

• Has the implementation been affected by external factors such as global change, ecosystems effects, or other fisheries?

Utility

• What trends in fleet capacity (kW or GT) would have been expected from the implementation of the plan? What trends were actually observed?

• Are the fleets affected by the management plan in a situation of overcapacity?

• Did the management plan contribute to adapting the fleet capacity to the fishing possibilities resulting from the management plan?

Efficiency (cost-effectiveness)

• What have been the costs of this plan in terms of for example employment, gross revenue of the fleet?

• Have there been any effects on the broader industry (processing, transporting, auxiliary)?

• What have been economic benefit/loss during the period of implementation? STECF will require guidance on to whom this applies.

Indicators

• Were the indicators used sufficiently useful to evaluate the multi-annual plan?

Sustainability

From the experience so far,

• Is it possible to draw conclusions about the sustainability of the plan that differ from those envisaged by the initial impact assessment?

7. CONCLUSIONS

Based on the answers to previous questions, *please give us your global judgement on the plan*

• With regards to the utility and sustainability of the multi-annual plan and its contribution to the objectives of the Common Fisheries Policy.

• Is the plan succeeding in achieving its stated objectives

• Which elements of the plan have had the greatest influence in achieving the objectives.

• Are there any specific indicators that would be useful for a future evaluation of this multi-annual plan?

• Are there any additional data that should be collected in the future to help in evaluating the multi-annual plan?

• Should the plan be linked to other plans?

• Are there any elements of the plan that require revision? What are the proposals for revision?

ANNEX B: COUNCIL REGULATION (EC) NO 1098/2007 OF 18 SEPTEMBER 2007

Establishing a multiannual plan for the cod stocks in the Baltic Sea and the fisheries exploiting those stocks, amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 779/97

I

(Acts adopted under the EC Treaty/Euratom Treaty whose publication is obligatory)

REGULATIONS

COUNCIL REGULATION (EC) No 1098/2007

of 18 September 2007

establishing a multiannual plan for the cod stocks in the Baltic Sea and the fisheries exploiting those stocks, amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 779/97

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 37 thereof,

Having regard to the proposal from the Commission,

Having regard to the Opinion of the European Parliament [1],

Whereas:

(1) Recent scientific advice from the International Council for the Exploration of the Sea (ICES) indicates that the cod stock in ICES Subdivisions 25 to 32 of the Baltic Sea has declined to levels where it is suffering from reduced reproductive capacity and that the stock is being harvested unsustainably.

(2) Recent scientific advice from ICES indicates that the cod stock in ICES Subdivisions 22, 23 and 24 of the Baltic Sea is over-exploited and has reached levels where it is at risk of reduced reproductive capacity.

(3) Measures need to be taken to establish a multiannual plan for fisheries management of the cod stocks in the Baltic Sea.

(4) The objective of the plan is to ensure that Baltic cod stocks can be exploited under sustainable economic, environmental and social conditions.

(5) Council Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the common fisheries policy [2] requires, *inter alia*, that to achieve that objective, the Community is to apply the precautionary approach in taking measures to protect and conserve the stock, to provide for its sustainable exploitation and to reduce to a minimum the impact of fishing on marine ecosystems. It should aim at a progressive implementation of an ecosystem-based approach to fisheries management, and should contribute to efficient fishing activities within an economically viable and competitive fisheries industry, providing a fair standard of living for those who depend on fishing Baltic cod and taking the interests of consumers into account.

(6) In order to achieve the objective, the Eastern stock must be rebuilt to safe biological limits and, for both stocks, levels must be ensured at which their full reproductive capacity is maintained and the highest long-term yields can be reached.

(7) This can be achieved by establishing an appropriate method for gradually reducing the fishing effort in fisheries catching cod to levels that are consistent with the objective, and by fixing the total allowable catches (TACs) for the cod stocks at levels consistent with the fishing effort.

(8) As catches of cod in the fisheries for herring and sprat and in gillnet and entangling-net fisheries for salmon are very limited, these fisheries should not be subject to the gradual reduction in fishing effort.

(9) To ensure stability in the fishing possibilities, it is appropriate to limit the variation in the TACs from one year to the next.

(1) Opinion of 7 June 2007 (not yet published in the Official Journal).

(2) OJ L 358, 31.12.2002, p. 59.

(10) An appropriate implementation of the control of fishing effort is to regulate the length of the periods when cod fishing is allowed. Member States may set common days when all Community vessels flying their flag are allowed to be absent from port.

(11) Control measures are needed in addition to or by way of derogation from those laid down in Council Regulation (EC) No 1627/94 of 27 June 1994 laying down general provisions concerning special fishing permits ([1]), Council Regulation (EEC) No 2847/93 of 12 October 1993 establishing a control system applicable to the common fisheries policy ([2]) and Commission Regulation (EEC) No 2807/83 of 22 September 1983 laying down detailed rules for recording information on Member States' catches of fish ([3]) in order to ensure compliance with the measures laid down in this Regulation.

(12) During the first three years of its application, the multiannual plan should be deemed to be a recovery plan within the meaning of Article 5 of Regulation (EC) No 2371/2002.

(13) ICES Subdivision 27 or 28 might be excluded from the provisions for the management of fishing effort due to minimal catches in these ICES Subdivisions.

(14) The multiannual plan provided for in this Regulation replaces the existing arrangements on the management of fishing effort in the Baltic Sea. Therefore, Council Regulation (EC) No 779/97 of 24 April 1997, introducing arrangements for the management of fishing effort in the Baltic Sea ([4]) should be repealed,

HAS ADOPTED THIS REGULATION:

CHAPTER I

SUBJECT MATTER, SCOPE AND DEFINITIONS

Article 1

Subject matter

This Regulation establishes a multiannual plan for the following cod stocks (hereinafter referred to as 'the cod stocks concerned') and the fisheries exploiting those stocks:

(a) cod which inhabits Area A;

(b) cod which inhabits Areas B and C.

Article 2

Scope

This Regulation shall apply to Community fishing vessels with an overall length equal to or greater than eight meters operating in the Baltic Sea and Member States bordering the Baltic Sea (hereinafter referred to as the 'Member States concerned'). However, Article 9 shall apply to vessels with an overall length below eight meters operating in the Baltic Sea.

Article 3

Definitions

For the purposes of this Regulation, the following definitions shall apply in addition to those laid down in Article 3 of Regulation (EC) No 2371/2002 and Article 2 of Council Regulation (EC) No 2187/2005 of 21 December 2005 for the conservation of fishery resources through technical measures in the Baltic Sea, the Belts and the Sound ([5]):

(a) the International Council for the Exploration of the Sea (ICES) Divisions and Subdivisions are as defined in Council Regulation (EEC) No 3880/91 of 17 December 1991 on the submission of nominal catch statistics by Member States fishing in the north-east Atlantic ([6]);

(b) 'Baltic Sea' means ICES Divisions IIIb, IIIc and IIId;

(c) 'total allowable catch (TAC)' means the quantity that can be taken from each stock each year;

(d) 'VMS' means vessel monitoring systems according to Commission Regulation (EC) No 2244/2003 of 18 December 2003 laying down detailed provisions regarding satellite-based Vessel Monitoring Systems ([7]) for vessels of any length;

(e) 'Area A' means ICES Subdivisions 22 to 24;

'Area B' means ICES Subdivisions 25 to 28;

'Area C' means ICES Subdivisions 29 to 32;

([1]) OJ L 171, 6.7.1994, p. 7.
([2]) OJ L 261, 20.10.1993, p. 1. Regulation as last amended by Regulation (EC) No 1967/2006 (OJ L 409, 30.12.2006, p. 11).
([3]) OJ L 276, 10.10.1983, p. 1. Regulation as last amended by Regulation (EC) No 1804/2005 (OJ L 290, 4.11.2005, p. 10).
([4]) OJ L 113, 30.4.1997, p. 1.
([5]) OJ L 349, 31.12.2005, p. 1.
([6]) OJ L 365, 31.12.1991, p. 1. Regulation as last amended by Commission Regulation (EC) No 448/2005 (OJ L 74, 19.3.2005, p. 5).
([7]) OJ L 333, 20.12.2003, p. 17.

(f) 'days absent from port' means any continuous period of 24 hours or part thereof during which the vessel is absent from port.

CHAPTER II

OBJECTIVE AND TARGETS

Article 4

Objective and targets

The plan shall ensure the sustainable exploitation of the cod stocks concerned by gradually reducing and maintaining the fishing mortality rates at levels no lower than:

(a) 0,6 on ages 3 to 6 years for the cod stock in Area A; and

(b) 0,3 on ages 4 to 7 years for the cod stock in Areas B and C.

CHAPTER III

TOTAL ALLOWABLE CATCHES

Article 5

Setting of TACs

1. Each year, the Council shall decide by a qualified majority on the basis of a proposal from the Commission on the TACs for the following year for the cod stocks concerned.

2. The TACs for the cod stocks concerned shall be set in accordance with Articles 6 and 7.

Article 6

Procedure for setting the TACs for the cod stocks concerned

1. The Council shall adopt the TAC for the cod stocks concerned that, according to a scientific evaluation carried out by the Scientific, Technical and Economic Committee for Fisheries (STECF), is the higher of:

(a) the TAC that would result in a 10 % reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year;

(b) the TAC that would result in the level of fishing mortality rate defined in Article 4.

2. Where the application of paragraph 1 would result in a TAC that exceeds the TAC for the preceding year by more than 15 %, the Council shall adopt a TAC which is 15 % greater than the TAC of that year.

3. Where the application of paragraph 1 would result in a TAC that is more than 15 % below the TAC of the preceding year, the Council shall adopt a TAC which is 15 % less than the TAC of that year.

4. Paragraph 3 shall not apply where a scientific evaluation carried out by the STECF shows that the fishing mortality rate in the year of application of the TAC will exceed a value of 1 per year from the ages 3 to 6 years for the cod stock in Area A or a value of 0,6 per year for the ages 4 to 7 years for the cod stock in Areas B and C.

Article 7

Derogation

By way of derogation from Article 6, the Council may, where it considers this appropriate, adopt a TAC that is below the TAC that follows from applying Article 6.

CHAPTER IV

FISHING EFFORT LIMITATION

Article 8

Procedure for setting periods when fishing with certain types of gear is allowed

1. It shall be prohibited for fishing vessels to fish with trawls, Danish seines or similar gear of a mesh size equal to or larger than 90 mm, with gillnets, entangling nets or trammel nets of a mesh size equal to or larger than 90 mm, with bottom set lines, longlines except drifting lines, handlines and jigging equipment:

(a) from 1 to 30 April in Area A; and

(b) from 1 July to 31 August in Area B.

2. When fishing with drifting lines no cod shall be retained on board.

3. The Council shall decide each year by a qualified majority on the maximum number of days absent from port outside the periods specified in paragraph 1 in the following year when fishing with the gear referred to in paragraph 1 is allowed, in accordance with the rules set out in paragraphs 4 and 5.

4. Where the fishing mortality rate for one of the cod stocks concerned has been estimated by the STECF to be at least 10 % higher than the minimum fishing mortality rate defined in Article 4, the total number of days when fishing with the gear referred to in paragraph 1 is allowed shall be reduced by 10 % compared to the total number of days allowed in the current year.

5. Where the fishing mortality rate for one of the cod stocks concerned has been estimated by the STECF to be less than 10 % above the minimum fishing mortality rates defined in Article 4, the total number of days where fishing with the gear referred to in paragraph 1 is allowed shall be equal to the total number of days allowed in the current year, multiplied by the minimum fishing mortality rate defined in Article 4 divided by the fishing mortality rate estimated by STECF.

6. By way of derogation from paragraph 1, fishing vessels with an overall length of less than 12 metres shall be permitted to use up to five days per month divided into periods of at least two consecutive days from the maximum number of days absent from port resulting from the application of paragraphs 3 to 5 during the closed periods referred to in paragraph 1. During these days, fishing vessels may only immerse their nets and land fish from 06.00 on Monday to 18.00 on Friday of the same week.

Article 16 shall apply to the fishing vessels referred to in the first subparagraph without holding a permit for fishing for cod.

7. At the request of the Commission or a Member State, Member States shall make available on their website or provide to the Commission and all Member States a description of the system applied to ensure compliance with paragraphs 3, 4 and 5.

Article 9

Area restrictions on fishing

1. It shall be prohibited to conduct any fishing activity from 1 May to 31 October within the areas enclosed by sequentially joining with rhumb lines the following positions, which shall be measured according to the WGS84 coordinate system:

(a) Area 1:

— 55° 45′ N, 15° 30′ E

— 55° 45′ N, 16° 30′ E

— 55° 00′ N, 16° 30′ E

— 55° 00′ N, 16° 00′ E

— 55° 15′ N, 16° 00′ E

— 55° 15′ N, 15° 30′ E

— 55° 45′ N, 15° 30′ E

(b) Area 2:

— 55° 00′ N, 19° 14′ E

— 54° 48′ N, 19° 20′ E

— 54° 45′ N, 19° 19′ E

— 54° 45′ N, 18° 55′ E

— 55° 00′ N, 19° 14′ E

(c) Area 3:

— 56° 13′ N, 18° 27′ E

— 56° 13′ N, 19° 31′ E

— 55° 59′ N, 19° 13′ E

— 56° 03′ N, 19° 06′ E

— 56° 00′ N, 18° 51′ E

— 55° 47′ N, 18° 57′ E

— 55° 30′ N, 18° 34′ E

— 56° 13′ N, 18° 27′ E.

2. By way of derogation from paragraph 1, fishing with gillnets, entangling nets and trammel nets of a mesh size equal to or larger than 157 mm or with drifting lines shall be permitted. No other gear shall be kept on board.

3. When fishing with any of the gear types defined in paragraph 2, no cod shall be retained on board.

CHAPTER V

MONITORING, INSPECTION AND SURVEILLANCE

Article 10

Special permit for fishing for cod in the Baltic Sea

1. By way of derogation from Article 1(2) of Regulation (EC) No 1627/94, all Community vessels of an overall length equal to or greater than eight metres carrying on board or using any gears for cod fishing in the Baltic Sea in accordance with Article 3 of Regulation (EC) No 2187/2005 shall hold a special permit for fishing for cod in the Baltic Sea.

2. Member States may issue the special permit for fishing for cod referred to in paragraph 1 only to Community vessels holding in 2005 a special permit for fishing for cod in the Baltic Sea in accordance with point 6.2.1 of Annex III to Council Regulation (EC) No 27/2005 of 22 December 2004 fixing for 2005 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required [1]. However, a Member State may issue a special permit for fishing for cod to a Community vessel, flying the flag of that Member State, not holding a special fishing permit in 2005 if it ensures that at least an equivalent capacity, measured in kilowatts (kW), is prevented from fishing in the Baltic Sea with any gear referred to in paragraph 1.

[1] OJ L 12, 14.1.2005, p. 1. Regulation as last amended by Regulation (EC) No 1936/2005 (OJ L 311, 26.11.2005, p. 1).

3. Each Member State concerned shall establish and maintain a list of vessels holding a special permit for fishing for cod in the Baltic Sea and make it available on its official website.

4. The master of a fishing vessel, or his authorised representative, to which a Member State has issued a special permit for fishing for cod in the Baltic Sea shall keep a copy of such permit on board the fishing vessel.

Article 11

Logbooks

1. By way of derogation from Article 6(4) of Regulation (EEC) No 2847/93, the masters of all Community vessels of an overall length equal to or greater than eight metres shall keep a logbook of their operations in accordance with Article 6 of that Regulation.

Notwithstanding the first subparagraph fishing vessels of overall length between 8 and 10 meters having cod on board caught in Area C shall keep a logbook that complies with the provisions as set out in point 2 of Annex IV to Regulation (EEC) No 2807/83.

2. For vessels fitted with VMS, Member States shall verify that the information received at the fisheries monitoring centres (FMC) corresponds to activities recorded in the logbook by using VMS data. Such cross-checks shall be recorded in computer-readable form for a period of three years.

3. Each Member State shall maintain and make available on its official website the contact details for the submission of logbooks, landing declarations and prior notifications as specified in Article 17.

Article 12

Electronic recording and transmission of catch data

By way of derogation from Article 1 of Regulation (EEC) No 2807/83, Member States may permit the master of a fishing vessel equipped with VMS to report the information required in the logbook by electronic means. The information shall be transmitted to the FMC of the flag Member State on a daily basis after the fishing operation of that calendar day has been completed. The logbook information shall be made available on the request of the FMC of the coastal State during the time the fishing vessel is in the waters of the coastal State and on the request of an inspection.

Article 13

Recording of fishing effort data

1. By way of derogation from Article 19b of Regulation (EEC) No 2847/93 the master of a Community fishing vessel, carrying on board any of the gears referred to in Article 8(1) of this Regulation when leaving and entering port, or entering and leaving the Baltic Sea, shall transmit an effort report containing the following information to the FMC of the flag Member State:

(a) When leaving port or entering the Baltic Sea:

  (i) The name of the vessel, external identification mark and radio call sign;

  (ii) The date and time of departure from port or entry into the Baltic Sea (local time);

  (iii) The area where the vessel will fish as defined in Article 3(e);

(b) When entering port or leaving the Baltic Sea:

  (i) The name of the vessel, external identification mark and radio call sign;

  (ii) The date and time of entry into port or exit from the Baltic Sea (local time).

2. Points (i) and (ii) of paragraph 1(a) and paragraph 1(b) shall not apply to vessels equipped with VMS.

3. The FMC of the flag Member State shall record the effort report it in its computerised database.

4. On request the flag Member State shall provide the information referred to in paragraph 1 to the coastal Member State.

Article 14

Monitoring and control of fishing effort

The competent authorities of the flag Member State shall monitor and control the compliance with:

(a) fishing effort limits provided for in Article 8;

(b) restrictions on fishing provided for in Article 9.

Article 15

Margin of tolerance in the logbook

By way of derogation from Article 5(2) of Regulation (EEC) No 2807/83, the permitted margin of tolerance in estimating quantities, in kilograms, of fish subject to a TAC that are retained on board vessels shall be 10 % of the logbook figure except for cod in which case the margin of tolerance shall be 8 %.

For catches taken in Area A and B which are landed unsorted the permitted margin of tolerance in estimating quantities shall be 10 % of the total quantity that are retained on board.

Article 16

Entry into or exit from specific areas

1. A fishing vessel having a special permit for fishing for cod may only fish in either Areas A, B or C during one fishing trip.

2. A fishing vessel may only commence fishing activity in Community waters in either Areas A, B or C with no cod on board.

If the fishing vessel goes to a port, without landing its fish, within the area where it has been fishing the vessel may continue its fishing activity in that area with cod on board.

3. When a fishing vessel exits from either Areas A, B or C with cod on board it shall:

(a) go directly to port outside the Area where it has been fishing and land the fish;

(b) when leaving the Area where the vessel has been fishing, stow the nets in accordance with the following conditions so that they may not readily be used:

(i) nets, weights and similar gear shall be disconnected from their trawl boards and towing and hauling wires and ropes;

(ii) nets which are on or above deck shall be securely lashed to some part of the superstructure.

4. By way of derogation to paragraphs 1, 2 and 3 a fishing vessel may fish in areas A and B during one fishing trip and may commence fishing activity in either of the areas only with less than 150 kg of cod on board in the year 2008. Member States shall take specific measures to ensure effective control. Member States shall report on those measures to the Commission by 31 January 2008.

Article 17

Prior notification

1. The master of a Community fishing vessel exiting from Area A, B or C with more than 300 kg of live weight of cod on board shall notify the competent authorities of the Coastal State in which it will land the fish at least one hour before leaving the Area of:

(a) the time and position of exit;

(b) the quantities of cod and the total weight of other species in live weight retained on board;

(c) the name of the landing location;

(d) the estimated time of arrival at the landing location.

The Coastal State shall notify the flag State of the landing.

2. When a Community fishing vessel intends to enter a port in the area where it has been fishing with more than 300 kg of live weight of cod on board the master of a Community fishing vessel shall notify the competent authorities of the Coastal State and the Coastal State shall notify the flag state at least one hour before entering port all the information referred to in points (b), (c) and (d) of paragraph 1.

3. The submission of information referred to in points (a) and (b) of paragraph 1 shall not apply to vessels subject to Article 12.

4. Paragraph 1(a) shall not apply to vessels equipped with VMS.

5. The notification provided for in paragraphs 1 and 2 may also be made by a representative of the master of the Community fishing vessel.

Article 18

Designated ports

1. When a vessel retains more than 750 kilograms of cod live weight, the cod may be landed exclusively at designated ports.

2. Each Member State may designate ports at which any quantity of Baltic cod live weight in excess of 750 kilograms is to be landed.

3. By 10 October 2007 each Member State that has established a list of designated ports, shall maintain and make available on its official website a list of designated ports.

Article 19

Weighing of cod first landed

The master of a fishing vessel shall ensure that any quantity of cod caught in the Baltic Sea and landed in a Community port shall be weighed before sale or before being transported elsewhere from the port of landing. The scales used for the weighing shall be approved by the competent national authorities. The figure resulting from the weighing shall be used for the declaration referred to in Article 8 of Regulation (EEC) No 2847/93.

Article 20

Inspection benchmarks

Each Member State of the Baltic Sea shall set specific inspection benchmarks. Such benchmarks shall be revised periodically after an analysis has been made of the results achieved. Inspection benchmarks shall evolve progressively until the target benchmarks defined in Annex I are reached.

Article 21

Prohibition on transiting and transhipping

1. Transit within areas closed for cod fishing is prohibited unless fishing gear on board is securely lashed and stowed in accordance with Article 16(3)(b).

2. The transhipment of cod is prohibited.

Article 22

Transport of Baltic cod

By way of derogation from Article 8(1) of Regulation (EEC) No 2847/93 the master of a fishing vessel having an overall length equal to or more than eight metres, shall complete a landing declaration when fish is transported to a place other than that of landing.

By way of derogation from Article 13(4) of Regulation (EEC) No 2847/93, the landing declaration shall accompany the transport documents provided for in Article 13(1) of that Regulation pertaining to the quantities transported. The exemption provided for in Article 13(4)(b) of that Regulation shall not apply.

Article 23

Joint surveillance and exchange of inspectors

Member States concerned shall undertake joint inspection and surveillance activities.

Article 24

National control action programmes

1. The Member States of the Baltic Sea shall define a national control action programmes for the Baltic Sea in accordance with Annex II.

2. The Member States of the Baltic Sea shall set specific inspection benchmarks in accordance with Annex I. Such benchmarks shall be revised periodically after an analysis has been made of the results achieved. Inspection benchmarks shall evolve progressively until the target benchmarks defined in Annex I are reached.

3. Before 31 January each year, the Member States of the Baltic Sea shall make available to the Commission and other Member States bordering the Baltic Sea on its official website their national control action programmes as referred to in paragraph 1, together with an implementation schedule.

4. The Commission shall convene at least once a year a meeting of the Committee for Fisheries and Aquaculture to evaluate compliance with and the results of the national control action programmes for cod stocks in the Baltic Sea.

Article 25

Specific monitoring programme

By way of derogation from the fifth subparagraph of Article 34c(1) of Regulation (EEC) No 2847/93, the specific control and inspection programme for the cod stocks concerned may last for more than three years.

CHAPTER VI

FOLLOW-UP

Article 26

Evaluation of the plan

1. The Commission shall, on the basis of advice from STECF and the Baltic Regional Advisory Council (RAC), evaluate the impact of the management measures on the stocks concerned and on the fisheries exploiting those stocks in the third year of application of this Regulation and in each of the following years.

2. The Commission shall seek scientific advice from STECF on the rate of progress towards the targets specified in Article 4 in the third year of application of this Regulation and every third successive year of its application. Where the advice indicates that the targets are unlikely to be met, the Council shall decide by a qualified majority on a proposal from the Commission on additional and/or alternative measures required to ensure that the objectives are met.

Article 27

Revision of minimum fishing mortality rates

Where the Commission, on the basis of advice from STECF, finds that the minimum fishing mortality rates given in Article 4 are disaccording with the objectives of the management plan, the Council shall on the basis of a Commission proposal decide by a qualified majority on revised minimum fishing mortality rates that are in accordance with the objective.

Article 28

European Fisheries Fund

During the first three years of its application, the multiannual plan shall be deemed to be a recovery plan within the meaning of Article 5 of Regulation (EC) No 2371/2002, and for the purpose of Article 21(a)(i) of Regulation (EC) No 1198/2006.

Article 29

ICES Subdivisions 27 and 28

1. Each year, and no later than 31 October, Member States fishing in Area B, shall submit a report of all catches and by-catches of cod taken during the preceding 12 months in Area B as well as the discards of that species specified by ICES Subdivision and by gear types referred to in Article 8(1) to the Commission.

2. Each year, and no later than 15 December, the Commission shall decide in accordance with the procedure laid down in Article 30(2) of Regulation (EC) No 2371/2002 and on the basis of the report from Member States referred to in paragraph 1 and the advice from the Scientific, Technical and Economic Committee for Fisheries to exclude ICES Subdivisions 27 and/or 28.2 from the restrictions provided for in Article 8(1)(b), (3), (4) and (5) and Article 13 if there is evidence that catches of cod in these ICES Subdivisions are lower than 3 % of the total catches of cod in Area B.

3. The exclusion of ICES Subdivisions 27 and/or 28.2 shall take effect from 1 January to 31 December of the following year.

4. Article 8(1)(b), (3), (4) and (5) shall not apply to ICES Subdivision 28.1. However, if there is evidence that catches of cod are higher than 1,5 % of the total catches of cod in Area B, Article 8(1)(b), (3), (4) and (5) shall apply and paragraphs 1, 2 and 3 of this Article are applicable.

CHAPTER VII

FINAL PROVISIONS

Article 30

Repeal

1. Council Regulation (EC) No 779/97 is hereby repealed.

2. Paragraph 1a of Article 19a of Regulation (EEC) No 2847/93 is hereby repealed.

Article 31

Entry into force

This Regulation shall enter into force on the third day following its publication in the *Official Journal of the European Union*.

It shall apply from 1 January 2008.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, 18 September 2007.

For the Council

The President

R. PEREIRA

ANNEX I

SPECIFIC INSPECTION BENCHMARKS

Objective

1. Each Member State shall set specific inspection benchmarks in accordance with this Annex.

Strategy

2. Inspection and surveillance of fishing activities shall concentrate on vessels likely to catch cod. Random inspections of transport and marketing of cod shall be used as a complementary cross-checking mechanism to test the effectiveness of inspection and surveillance.

Priorities

3. Different gear types shall be subject to different levels of prioritisation, depending on the extent to which the fleets are affected by fishing opportunity limits. For that reason, each Member State shall set specific priorities.

Target benchmarks

4. Not later than one month from the date of entry into force of this Regulation, Member States shall implement their inspection schedules taking account of the targets set out below.

   Member States shall specify and describe which sampling strategy will be applied.

   The Commission can have access on request to the sampling plan used by the Member State.

   (a) *Level of inspection in ports*

   As a general rule, the accuracy to be achieved should be at least equivalent to what would be obtained by a simple random sampling method, where inspections shall cover 20 % of all cod landings by weight in a Member State.

   (b) *Level of inspection of marketing*

   Inspection of 5 % of the quantities of cod offered for sale at auction.

   (c) *Level of inspection at sea*

   Flexible benchmark: to be set after a detailed analysis of the fishing activity in each area. Benchmarks at sea shall refer the number of patrol days at sea in the cod management areas, possibly with a separate benchmark for days patrolling specific areas.

   (d) *Level of aerial surveillance*

   Flexible benchmark: to be set after a detailed analysis of the fishing activity conducted in each area and taking the available resources at the Member State's disposal into consideration.

ANNEX II

CONTENTS OF NATIONAL CONTROL ACTION PROGRAMMES

National control action programmes shall aim, *inter alia*, to specify the following.

1. MEANS OF CONTROL

Human resources

1.1. The numbers of shore-based and seagoing inspectors and the periods and zones where they are to be deployed.

Technical resources

1.2. The numbers of patrol vessels and aircraft and the periods and zones where these are to be deployed.

Financial resources

1.3. The budgetary allocation for deployment of human resources, patrol vessels and aircraft.

2. ELECTRONIC RECORDING AND REPORTING OF INFORMATION RELATING TO FISHING ACTIVITIES

Description of the systems implemented to ensure compliance with Articles 13, 14, 15 and 18.

3. DESIGNATION OF PORTS

Where relevant, a list of ports designated for cod landings in accordance with Article 19.

4. ENTRY INTO OR EXIT FROM SPECIFIC AREAS

Description of the systems implemented to ensure compliance with Article 17.

5. LANDINGS CONTROL

Description of any facilities and or systems implemented to ensure compliance with the provisions in Articles 12, 16, 20, 22 and 23.

6. INSPECTION PROCEDURES

The national control action programmes shall specify the procedures that will be followed:

(a) when conducting inspections at sea and on land;

(b) for communicating with the competent authorities designated by other Member States as responsible for the national control action programme for cod;

(c) for joint surveillance and exchange of inspectors, including specification of powers and authority of inspectors operating in other Member States' waters.

ANNEX C: TRENDS IN FISHING EFFORT ALLOCATION, LANDINGS COMPOSITION, AND DISCARD BEHAVIOUR FOR NATIONAL FLEETS AND FISHERIES IN THE BALTIC SEA IN RELATION TO IMPLEMENTATION OF THE LONG TERM BALTIC COD MANAGEMENT PLAN

Introduction

Trends in international fishing effort and effort allocation, landings composition as well as changes in discards of cod in the Eastern and Western Baltic Sea were evaluated with focus on cod fisheries. This is in order to discriminate possible changes over the period before and after implementation of the long term Baltic cod management plan.

The long term Baltic cod management plan has been implemented in two phases. An initial phase was implemented from 2005-2007 and a full phase from 2008 and onwards.

Trends in total international fisheries effort in total hours at sea by year and fleet for the Eastern and Western Baltic Sea areas, respectively, are shown in Figures C.1 and C.2 as well as divided by season (quarter of year) in Figures C.3 and C.4 for the period 2004-2009. Fishing effort allocation in hours spent at sea by national DCF métier in the two areas are given in Figures C.5 and C.6 during the same period.

Distribution of landings and landings composition for the Danish, German and Swedish fisheries by DCF métier by season during the period 2004 to 2009 is shown in Figures C.7 and C.8.

Trends in discards of cod in the Eastern and Western Baltic combined for all countries are shown in Figures C.9 and C.10. Potential high-grading of Eastern Baltic cod in recent years is addressed based on Danish data (Figures C 11 and C 12)

Results

<u>Effort and species composition of landings</u>

During the period 2004-2009 there has been a general decline in effort for the most important fleets and fisheries catching cod both in both the Eastern and Western Baltic Sea areas, e.g. for the large-meshed demersal otter board single-trawls and large-meshed cod gillnets. This trend is rather general, and no specific tendencies and trends in effort for the different national fleets and fisheries can be detected directly associated with the implementation of the long term Baltic cod management plan.

The Eastern and Western Baltic cod stocks were historically among the largest and commercially most important cod stocks in the North-East Atlantic, and are exploited by several nations including Denmark, Poland, Sweden, Germany, Latvia, Russia and Lithuania (Bastardie *et al.,* 2010a,b). The cod fishery is mainly a single species multi-fleet fishery, and mixed fisheries issues are of minor importance as cod is the dominant species in the demersal fisheries (Bastardie *et al.,* 2010a,b). This is also illustrated in Figures C.7 and C.8 for the Danish, German and Swedish fisheries. However, the Western Baltic cod fishery is more mixed than the Eastern Baltic cod fishery. All in all, the fishing pattern, effort allocation, and fishing selectivity of Baltic cod are complex and vary considerably between gears, mesh sizes, countries, national fleets / fisheries, vessel size classes, seasons of year, and areas. The cod stocks are, consequently, exposed to spatial and seasonally targeted fishing behaviour. The main fishery is conducted with large-meshed demersal otterboard single-trawls and large-meshed cod gillnets. In more recent years, longline and hook fisheries have also become more frequent.

There can for the period 2004-2009 not be detected any specific trends or tendencies in landing compositions associated with the implementation of the long term cod management plan in the Danish, German and Swedish catch compositions by DCF metier from the Eastern and Western Baltic Sea, respectively (Figures C.7-8).

Cod discards

According to the discard estimates used in the ICES assessment, discards of the Eastern Baltic cod at age 1 have been substantially reduced since 2004 (Figure C. 9). The proportion of cod catch discarded at age 3 is indicated to have been about 15% higher in 2006-2009 compared to 2000-2005 (Figure C.9). The total numbers of cod discarded in the Western Baltic have been substantially lower in recent three years compared to earlier period, which is partly due to reduced overall level of catch. The proportion of catch of Western Baltic cod that has been discarded does not show major trends since 2000 (Figure C.10.).

Increased cod abundance in the Eastern Baltic in recent years could potentially give incentives for high-grading. Potential occurrence of high-grading was analysed only based on Danish data. To do so, cod landings structure (by sorting categories) from trips with an observer onboard was compared with size structure of cod landings from trips without an observer onboard. The results show that size structure of cod landings both in the Eastern and Western Baltic was similar regardless of whether observers were onboard or not (Figure C.11). Length-distribution of cod discards (from trips with an observer onboard) shows no indication of high-grading, as discard consisted of cod below minimum landing size (38 cm) both in the Eastern and Western Baltic. Similar size structure of cod landings when observers have not been onboard shows than high-grading has not been an issue in the Danish cod fisheries in the Baltic in recent years (analyses where based on data for 2009).

Potential influence of management plan

Possible impacts of the management plan on the fisheries effort and discard behavior as well as on the resulting landings composition and levels also have to be seen in context of a row of other external factors with significant influence on potential tendencies in effort, landings and discards as well, which have also occurred during the same period of time. Consequently, besides the introduction and implementation of the Baltic cod long term management plan in full (from 2008 onwards) a row of other parallel influencing factors on fisheries effort and landings levels and composition have been impacting and implemented such as:

Possible higher level of compliance / control + enforcement in the Baltic cod fishery from 2008 and onwards changing the perception of catch – also by ICES WGBFAS - and impacting SSB and F as well as effort ;

Fleet capacity changes and/ structural programs, e.g. the Polish decommissioning program from 2007-2008 onwards influencing effort and catch;

Increased oil prices from 2007-2008 onwards influencing effort;

Implementation of the Danish FKA regulation (ITQ on vessel basis) from 2008 onwards influencing fisheries behavior (effort, catch composition, discard);

Changes in cod landings prices, which have also occurred in the recent years;

Recent (from 2007-2008 onwards) changes in cod stock overall abundance levels, especially with respect to the higher recruitment in the Eastern Baltic Sea because of recent changes in hydrographical conditions, but also potential changes in relative abundances in certain areas, e.g. change in stock mixing in e.g. SD 24 because of relative high Eastern Baltic cod stock level compared to the Western Baltic cod stock level resulting in dominance of the former in mixing areas.

In relation to the long term Baltic cod management plan there have been reports that some national fleets (Denmark and Germany) have not been able to catch their full quotas with the relative effort levels given (Bastardie *et al.*, 2010a) on actual visited fishing grounds and their specific catch capacity. This is influenced as well of the underlying spatial distribution of the population (Bastardie et al., 2010b) which will influence the aggregated exploitation pattern when various quantitative and qualitative effort levels (fleet specific partial F's) are applied to different components of the population.

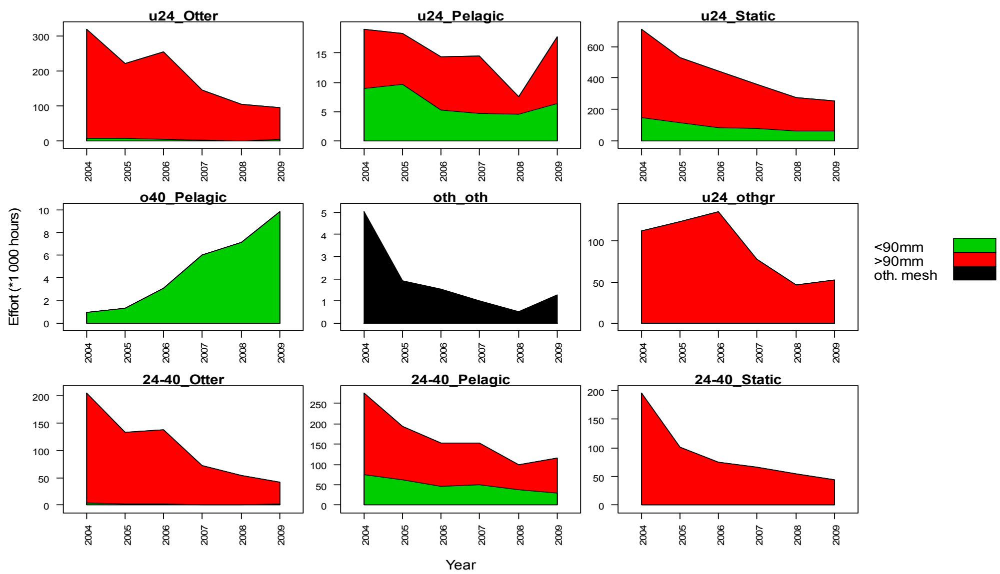


Figure C.1. Trends in yearly effort in total hours spent at sea for the full international fishery in the Eastern Baltic Sea by fishing fleet during the period 2004-2009.

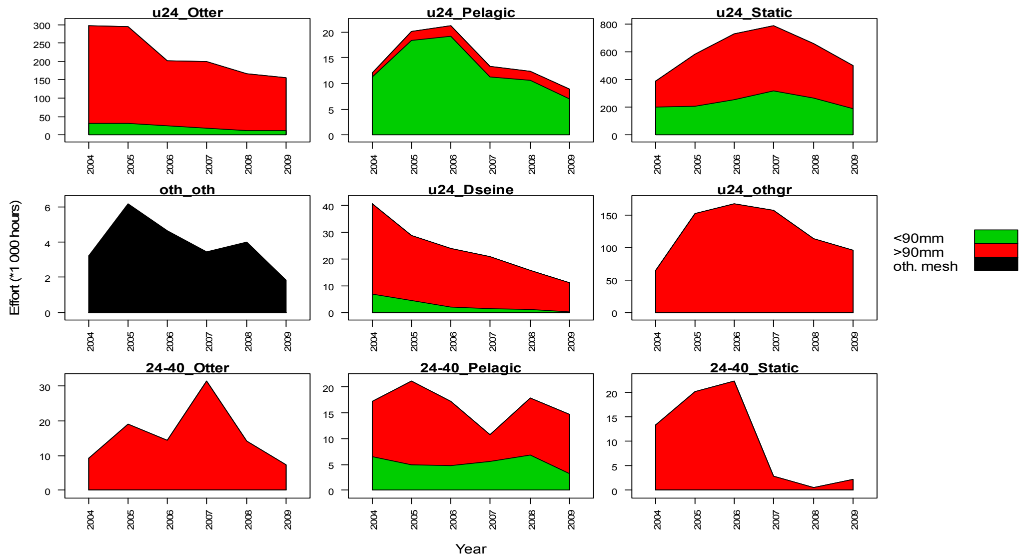


Figure C.2. Trends in yearly effort in total hours spent at sea for the full international fishery in the Western Baltic Sea by fishing fleet during the period 2004-2009.

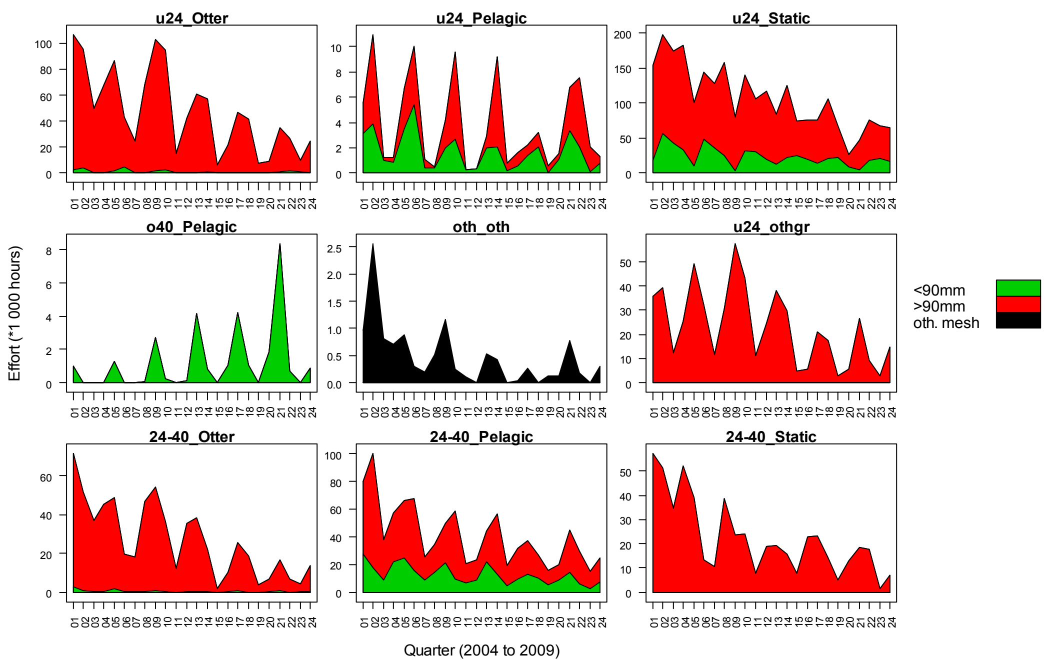


Figure C.3. Seasonal variation in effort in total hours spent at sea for the full international fishery in the Eastern Baltic Sea by fishing fleet during the period 2004-2009.

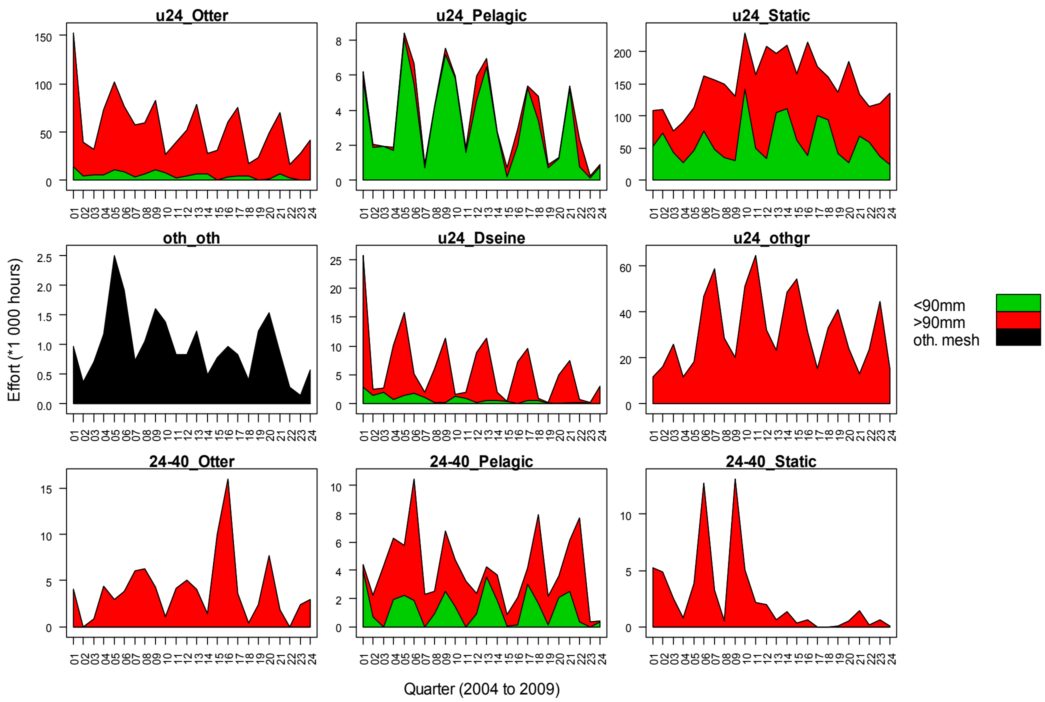


Figure C.4. Seasonal variation in effort in total hours spent at sea for the full international fishery in the Western Baltic Sea by fishing fleet during the period 2004-2009.

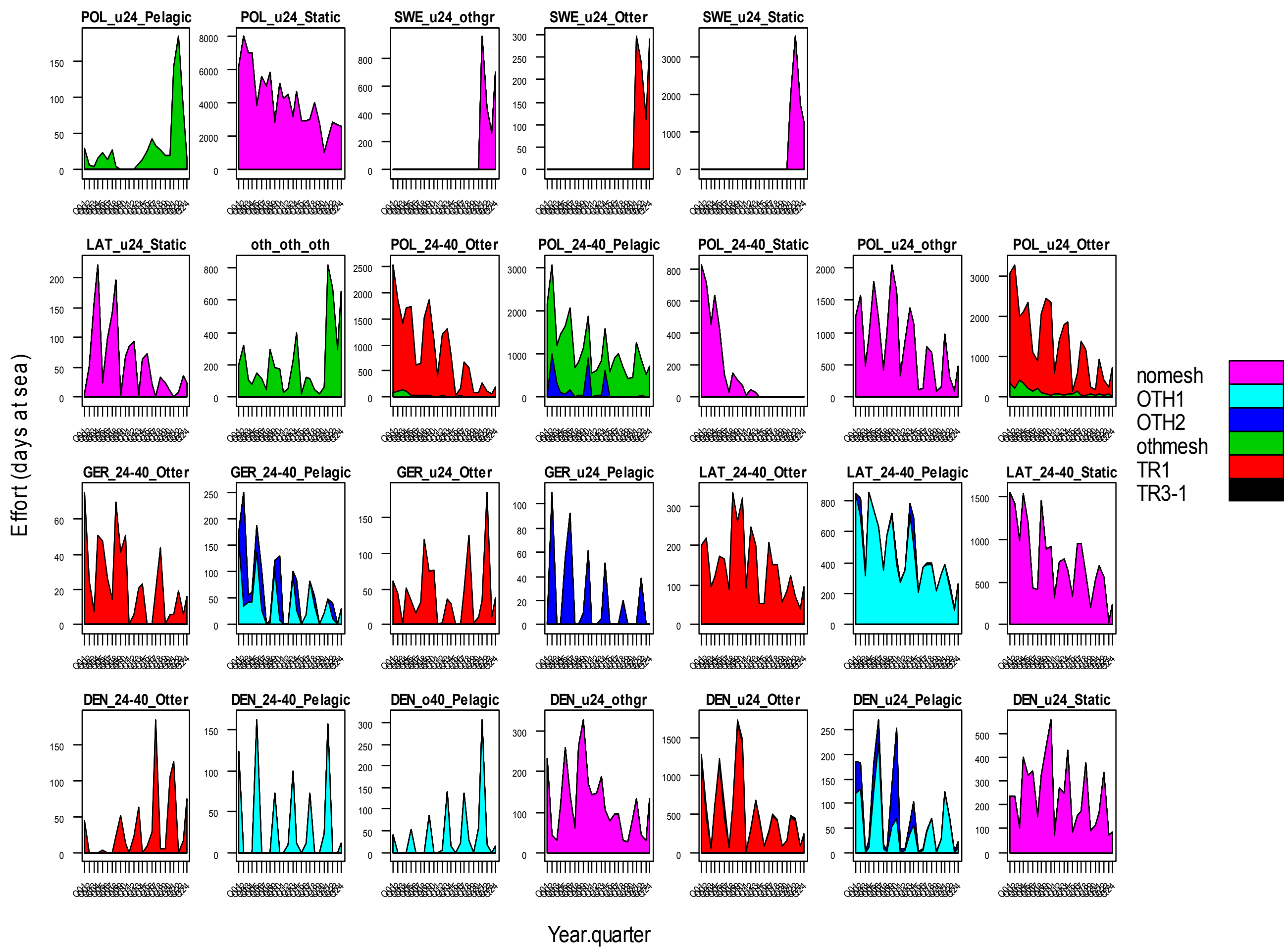


Figure C.5 Yearly trends and seasonal variation in effort in total hours spent at sea for the international fishery in the Eastern Baltic Sea by country and DCF métier (fishery).

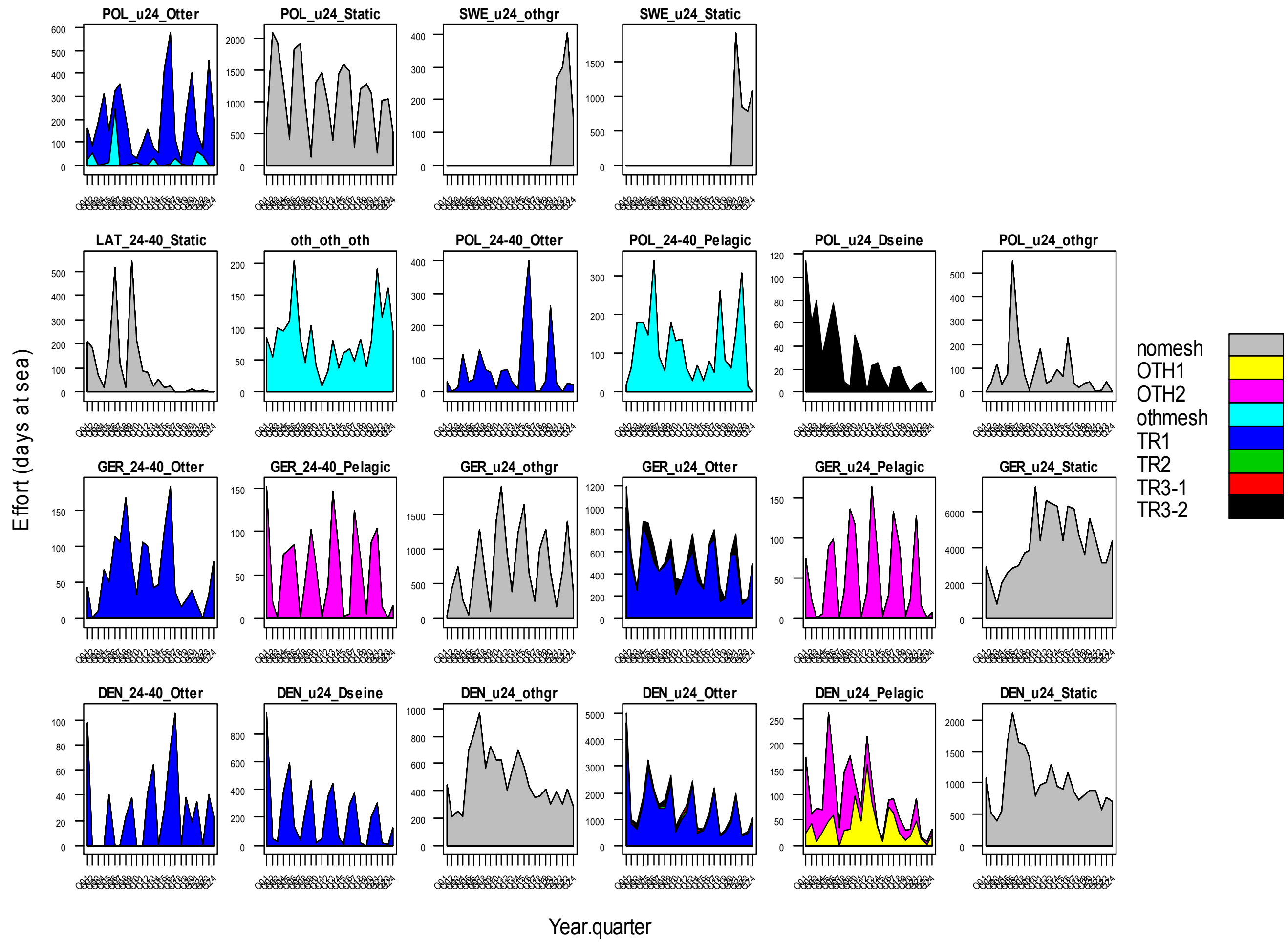


Figure C.6 Yearly trends and seasonal variation in effort in total hours spent at sea for the international fishery in the Western Baltic Sea by country and DCF métier (fishery).

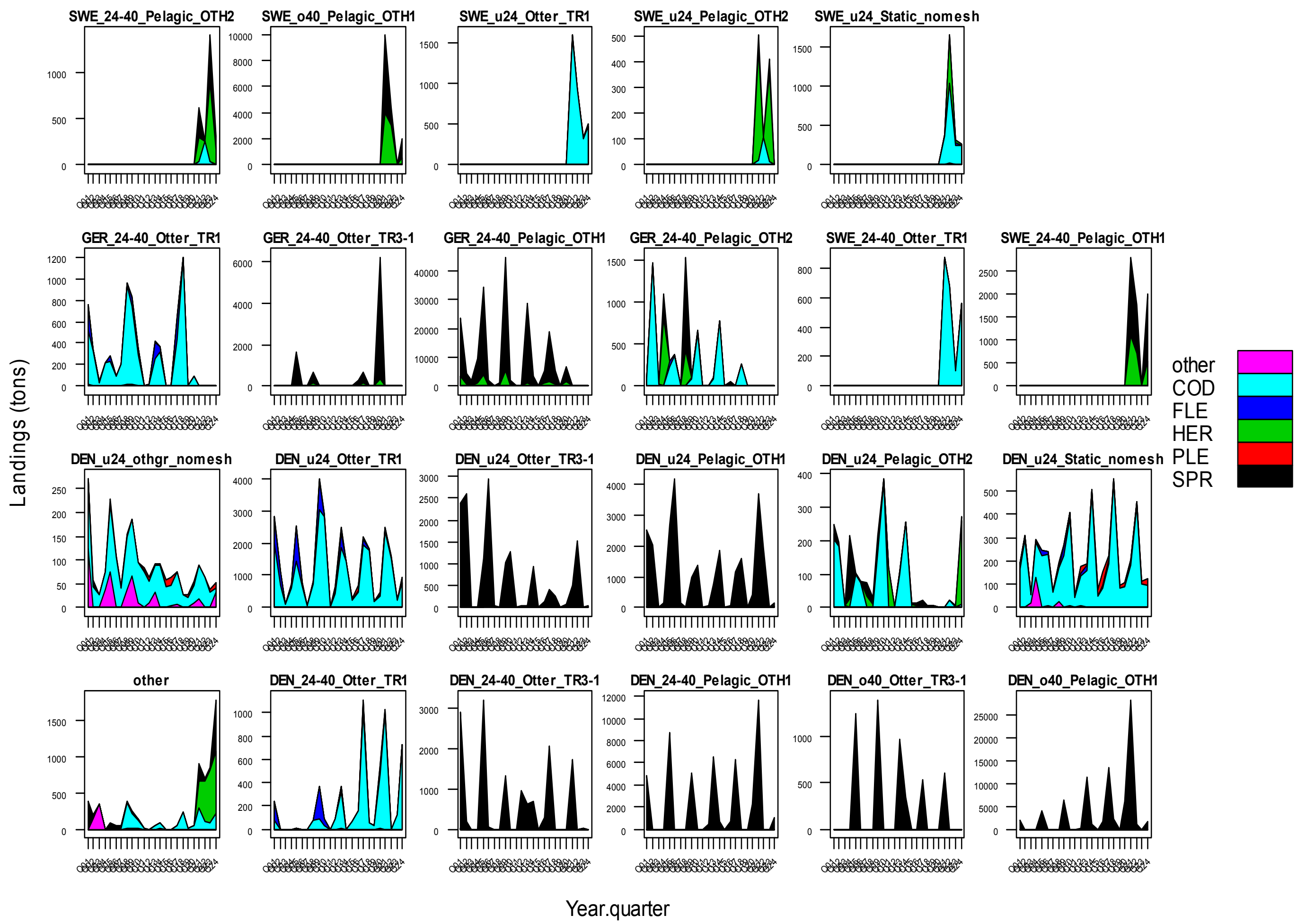


Figure C.7 Yearly trends and seasonal variation in landings composition (in tons) by species for the Danish, German and Swedish fishery in the Eastern Baltic Sea by DCF métier (fishery).

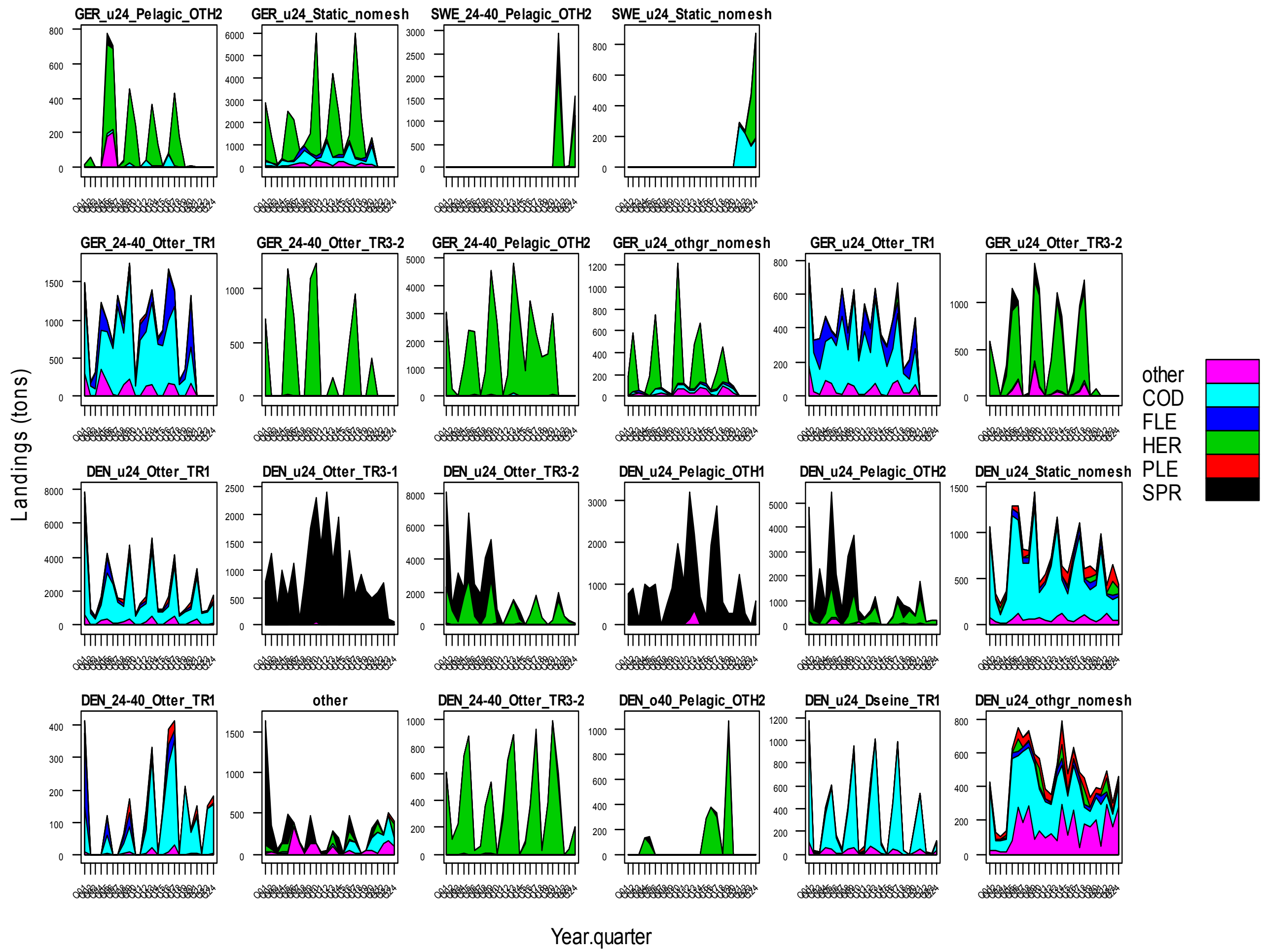


Figure C.8 Yearly trends and seasonal variation in landings composition (in tons) by species for the Danish, German and Swedish fishery in the Western Baltic Sea by DCF métier (fishery).

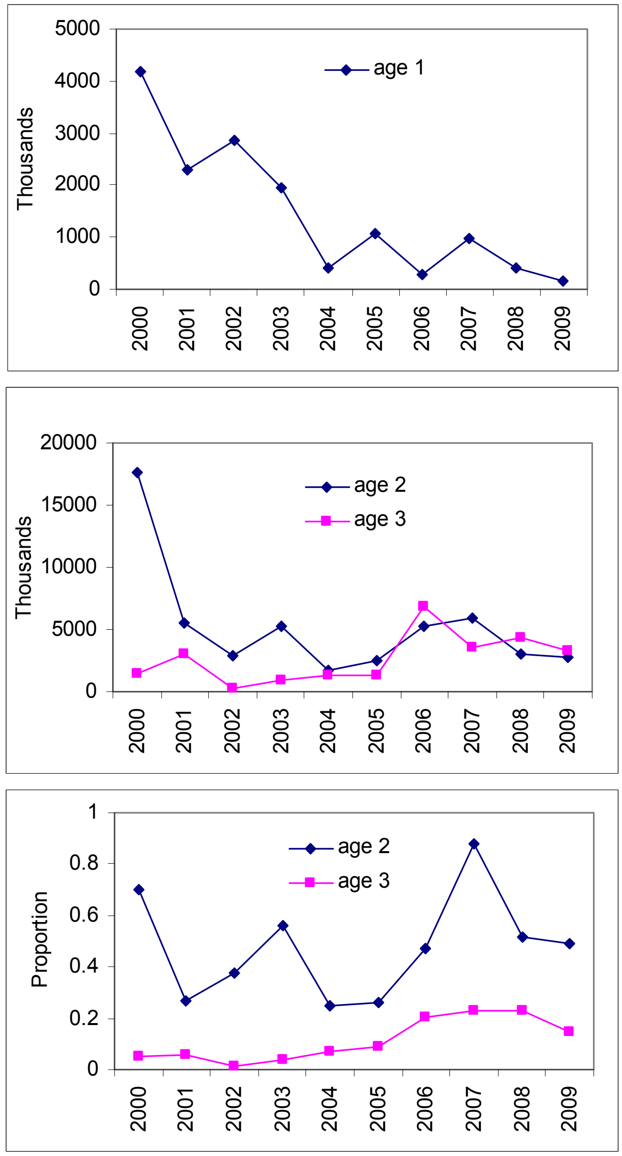


Figure C.9. Eastern Baltic cod discards (combined for all countries) as numbers by age-groups 1-3 and proportion of discards in catch (discard/(landings+discard)) for age-groups 2 and 3 (data from WGBFAS 2010).

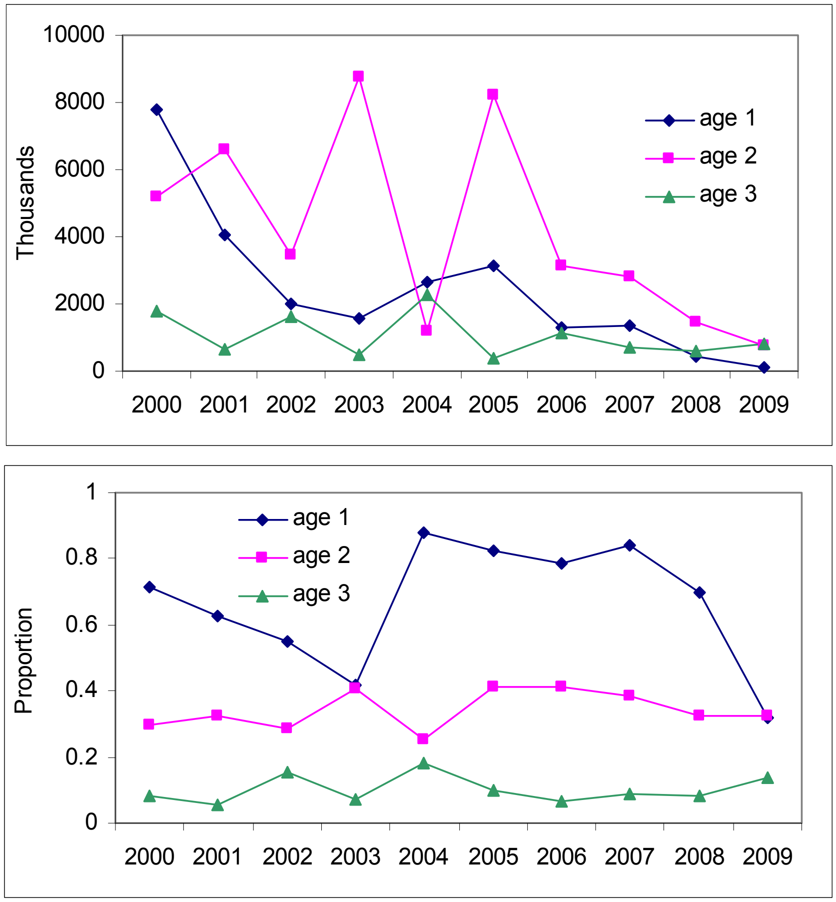
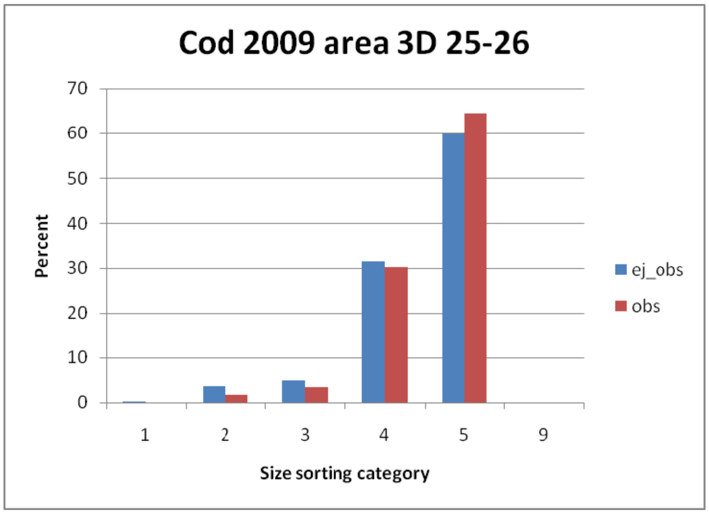
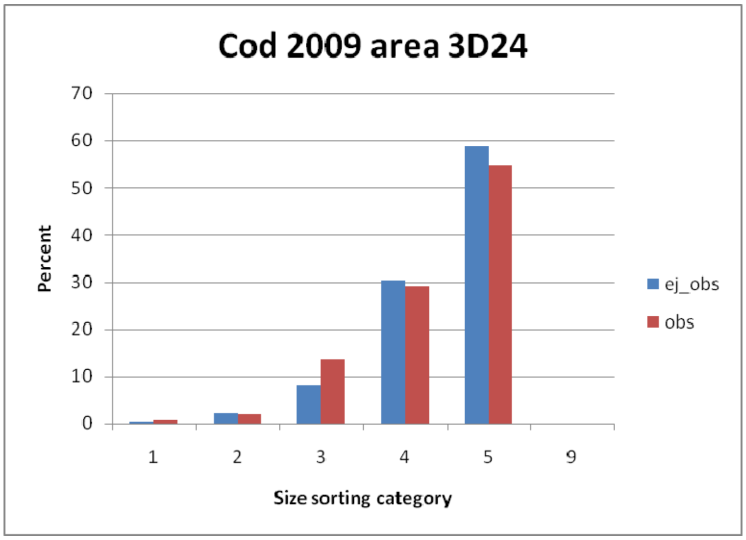


Figure C.10. Western Baltic cod discards (combined for all countries) as numbers by age-groups 1-3 and proportion of discards in catch (discard/(landings + discards)) (data from WGBFAS 2010).



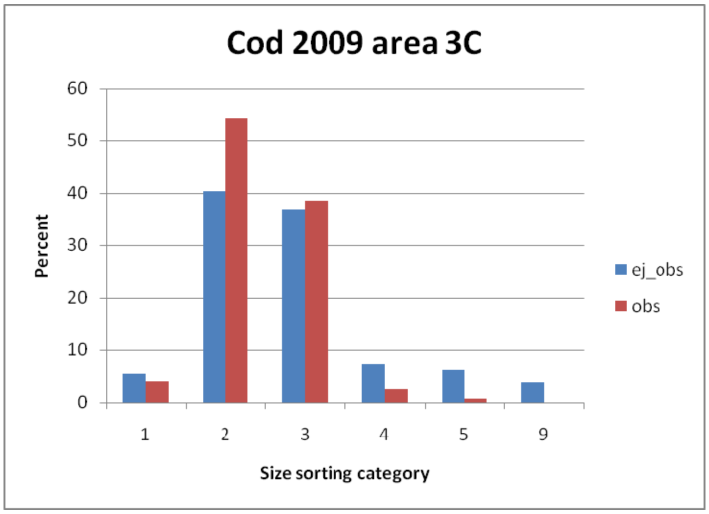
Size sorting category SD 25-26	Number of trips with observer	Number of trips without observer	Landings with observer (kg)	Landings without observer (kg)
1		53		15,208
2	6	1,667	755	280,409
3	28	3,459	1,502	387,232
4	35	4,754	13,071	2,441,864
5	35	4,153	27,951	4,659,782

Figure C. 11. a. Proportion of Danish cod landings in the Eastern Baltic (SD 25-26) in 2009 by size categories, separately for fishing trips with (red bars) and without (blue bars) an observer onboard. Categories from 1 to 5 represent size groups by weight from largest (1) to smallest (5) fish. (5: 0.3-1kg; 4: 1-2 kg; 3: 2-4 kg; 2: 4-7 kg; 1: >7 kg). The table below shows the underlying information in terms of number of trips and corresponding landings, which form the basis for the figure.



Size sorting category SD 24	Number of trips with observer	Number of trips without observer	Landings with observer (kg)	Landings without observer (kg)
1	2	252	299	20,659
2	2	1,032	846	119,534
3	17	3,594	6,105	445,430
4	18	4,912	12,998	1,665,095
5	21	4,534	24,453	3,217,919

Figure C. 11. b. Proportion of Danish cod landings in SD 24 in 2009 by size categories, separately for fishing trips with (red bars) and without (blue bars) an observer onboard. Categories from 1 to 5 represent size groups by weight from largest (1) to smallest (5) fish. (5: 0.3-1kg; 4: 1-2 kg; 3: 2-4 kg; 2: 4-7 kg; 1: >7 kg). The table below shows the underlying information in terms of number of trips and corresponding landings, which form the basis for the figure.



Size sorting category 3C	Number of trips with observer	Number of trips without observer	Landings with observer (kg)	Landings without observer (kg)
1	4	1,871	281	103,206
2	10	4,884	3,881	755,115
3	14	5,867	2,753	690,340
4	5	3,126	182	135,755
5	3	2,313	51	116,391

Figure C. 11. c. Proportion of Danish cod landings in the Western Baltic (in the area 3c) in 2009 by size categories, separately for fishing trips with (red bars) and without (blue bars) an observer onboard. Categories from 1 to 5 represent size groups by weight from largest (1) to smallest (5) fish. (5: 0.3-1kg; 4: 1-2 kg; 3: 2-4 kg; 2: 4-7 kg; 1: >7 kg). The table below shows the underlying information in terms of number of trips and corresponding landings, which form the basis for the figure.

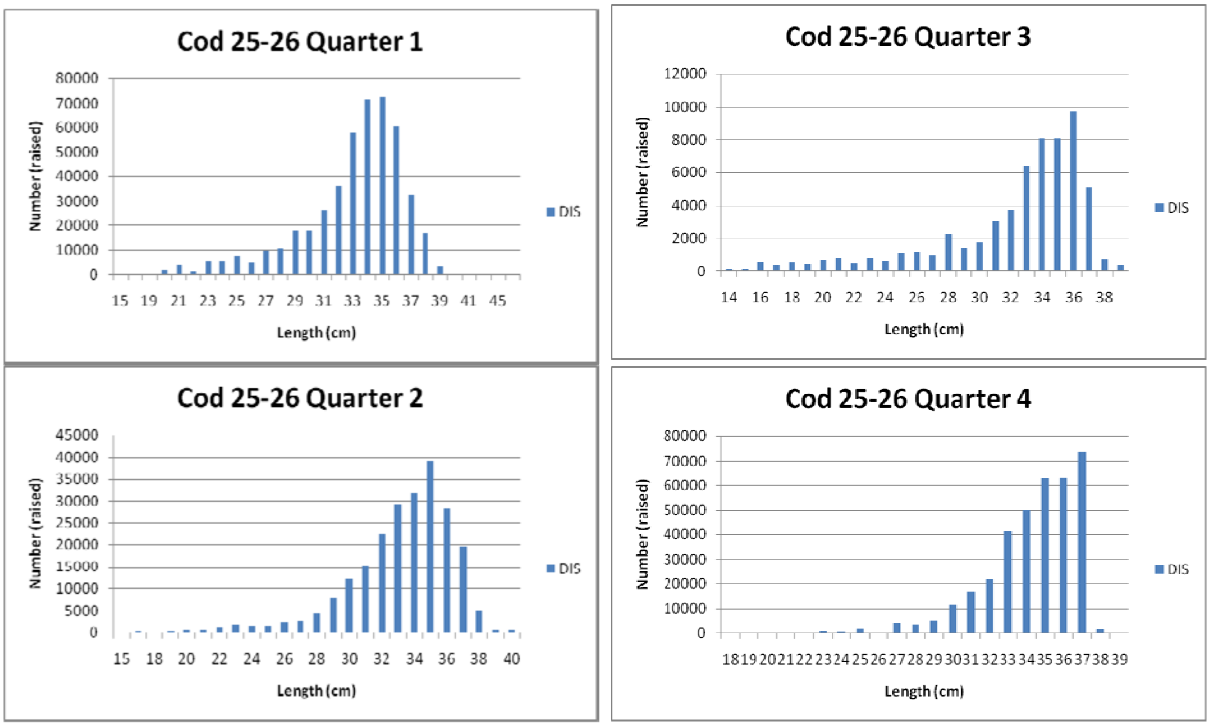


Figure C. 12.a. Length distribution of Danish cod discards in 2009 in the Eastern Baltic Sea (SD 25-26).

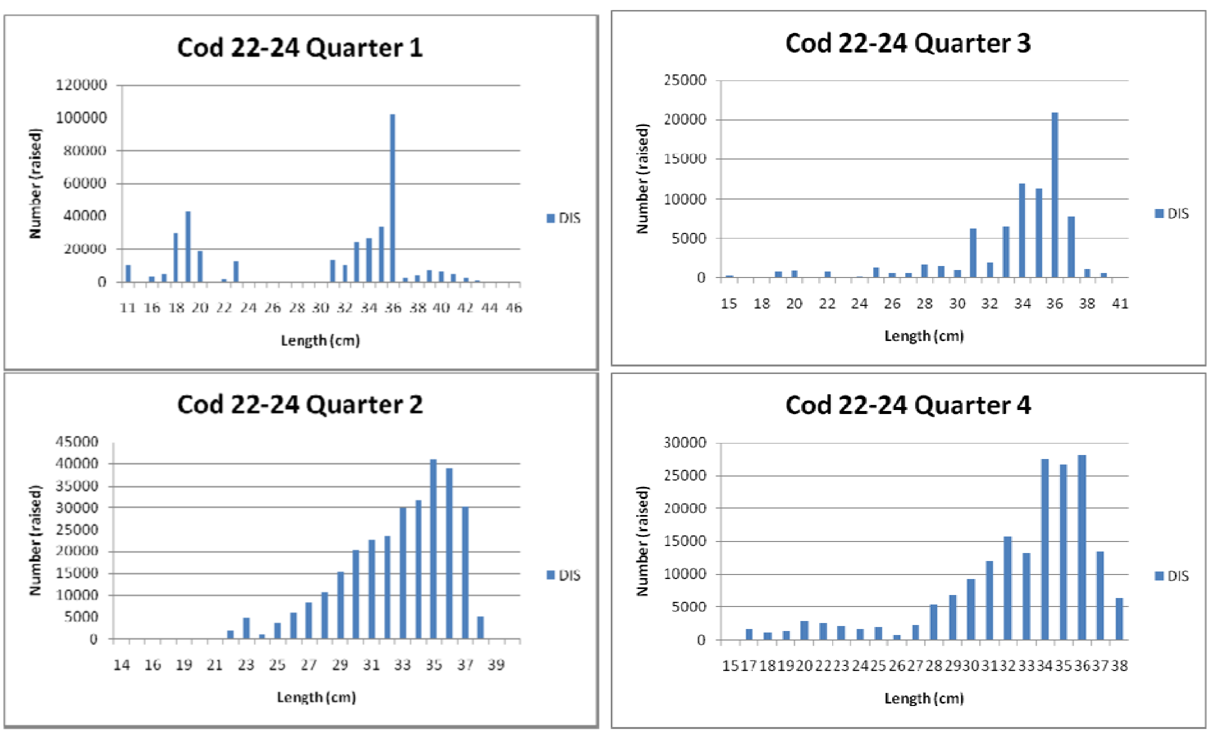


Figure C. 12.b. Length distribution of Danish cod discards in 2009 in the Western Baltic Sea (SD 22-24).

ANNEX D: CHANGES IN TECHNICAL MEASURES AND SELECTIVITY IN THE BALTIC COD TRAWL FISHERIES 1999-2010

Background

The selectivity of fishing gears and its effect on the populations of exploited fish species are important parameters when managing marine resources. Hence, one of the basic tools in European fishery management is to determine detailed technical measures, including gear regulations. The underlying aim of these regulations was to set up a framework which afford sustainable fishery. Unfortunately, technical measures were quite often very detailed and partly contradictory. This resulted in a) low acceptance by fishermen; b) difficulties to understand and control regulations; c) non sustainable use of fish resources (e.g. when selectivity of legal gears does not fit to minimum landing size).

In the Baltic trawl fishery for cod, several changes in technical measures were applied during the last years (Table D-3). Two council regulations (and their amendments) set up the framework for technical measures to be applied in the Baltic Sea cod fishery (88/1998 and 2187/2005). Additionally, technical measures, including gear regulations were introduced in annual council regulations fixing fishing opportunities (and their amendments). A major step in gear change in the Baltic Sea took place when T0-gears with their poor selectivity were banned. For some years, the BACOMA-cod end was the only legal gear (08/2003-01/2006). Unfortunately, the mesh opening of the BACOMA-window was reduced in 08/2003 from 120mm to 110mm. The T90- cod end as an alternative to the BACOMA-cod was introduced in 01/2006. The T90 (110mm)-cod end had comparable selectivity properties compared to the BACOMA but is much cheaper due the usage of normal netting.

A next major change occurred in 2010 when the mesh opening of T90-cod end and BACOMA window was increased from 110mm to 120mm.

In addition to gear specification changes, the amount of discards is also determined by the minimum landing size (MLS). In 01/2003, the MLS was increased from 35cm to 38cm.

Aim of this document

The investigation of the effect of selectivity changes on the population dynamic of Baltic Sea cod is subject of ongoing studies (incl. a not yet finalized thesis). Therefore, predictions on the potential development of population and catches are not presented here. Moreover, this document contains a summary of selectivity for the gears, which were in use in the Baltic cod fishery since 1999.

As example, some selectivity curves are applied to the population structure in selected areas of the Baltic Sea to demonstrate the development of selectivity and the differences in gears.

This document solely deals with the trawl fishery for Baltic cod (even if “Baltic Sea cod fishery” is written).

Selectivity parameters

Based on Table D-3 and Table D-4, it can be seen, that during the last 12 years, eight gear types were in use in the Baltic Sea cod trawl fishery. In this analysis, gears were grouped, even if there are some changes in regulation for this specific gear type. For example, for T0-cod ends, no twine thickness was defined prior to 2002.

For these eight gear types, selectivity data were delivered by Harald Wienbeck (Institute of Baltic Sea Fisheries, Hamburg, Germany). All presented data (Table D-4) are derived from sea trials onboard RV "Solea". Due to experimental data, the used cod end mesh opening might slightly differ from nominal legal mesh size. For example, the investigations of the cod ends with 120mm nominal mesh opening (BACOMA, T90) in spring 2010 were conducted with standard netting delivered by German net makers, hence comparable mesh opening was also used by commercial fishermen. The mesh opening for these trials was significantly larger than nominal mesh size of 120mm (BACOMA-window: 129.8mm; T90: 127.8mm). Two trial series exist for BACOMA 120mm cod ends, one series from 2002/2003 and the other from 2010. The selectivity parameters for both series differ. Therefore, results of both series are given separately (BACOMA 120mm (2002); BACOMA 120mm (2010)).

For the present legal gears, calculated selectivity parameter will be given below.

All selectivity data presented here are derived from sea trials using the covered cod end method. Logit (formula (1)) curves were fitted to haul data using a maximum likelihood estimation, following the procedures described in Wileman et al. (1996):

$$r(l) = \frac{\exp\left(\left(l - L50\right) \times \frac{\ln(9)}{SR}\right)}{1 + \exp\left(\left(l - L50\right) \times \frac{\ln(9)}{SR}\right)} \qquad (1)$$

Where *r(l)* model the retention likelihood of a cod at length *l* given it enters the cod end. L50 is the 50% retention length and SR the selection range *(= L75 – L25)*. Hence, L50 and SR can be used to quantify the size selection of cod.

The temporal development of size selection in Baltic cod fishery is shown in Figure D-1. Additionally, minimum landing size is marked in the L50-figure (1999 – 2002: 35cm; 2003-2010: 38cm). It is obvious, that at least the selectivity of the T0-trawls did not fit to the MLS at this time. Additionally, it is shown, that L50 of BACOMA 110mm and T90 110mm were very close to MLS, resulting in potentially relatively high discards.

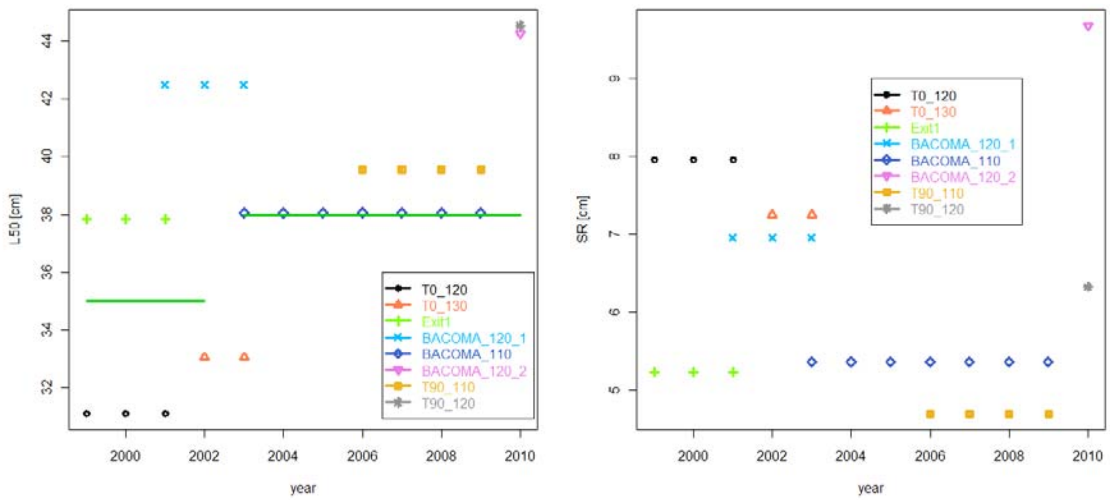


Figure D-1: Selection parameter (L50 left, SR right) of legalized cod ends for the Baltic cod fishery in certain years, based on experimental results. Left: green line represents the corresponding minimum landing size (MLS).

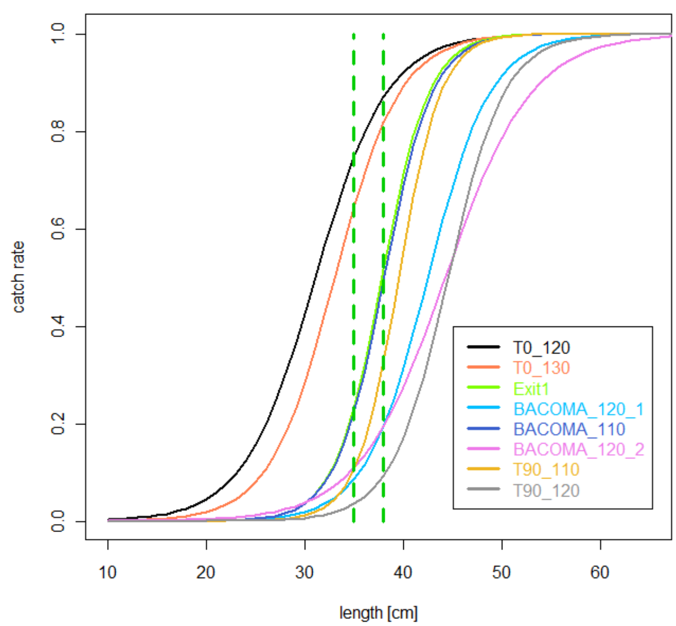


Figure D-2: Selection curves of legalized cod ends for the Baltic cod trawl fishery, based on experimental results. Dashed, green vertical line represents the corresponding minimum landing size (MLS; 35cm 1999-2002; 38cm 2003-2010).

Figure D-2 shows the selection curves of the eight gear types together with MLS. It is important to mention the less steep selection curve of BACOMA 120mm (trials in 2010), resulting in a relatively wide selection range.

The Institute for Baltic Sea Fisheries and DTU-Aqua further investigate this effect and possible solutions. A manuscript is in prep. and expected end of 2010. Due to these ongoing investigations and analysis, only preliminary explanation can be given.

In contrast to the T90 trawl, the BACOMA cod end is made of two types of netting. Since the introduction of the BACOMA cod end, the cod end is made of T0 105mm-netting, except of the BACOMA-window (Figure D-3). Of course, both nettings (T0 105mm and BACOMA window) have different selectivity properties. The overall selection of the BACOMA-cod end is a combination of both selectivities (dual selectivity). With the increase of mesh opening of the BACOMA-window from 110mm to 120mm in 2010, the difference in selectivity between both netting increased, resulting in an increase in selection range.

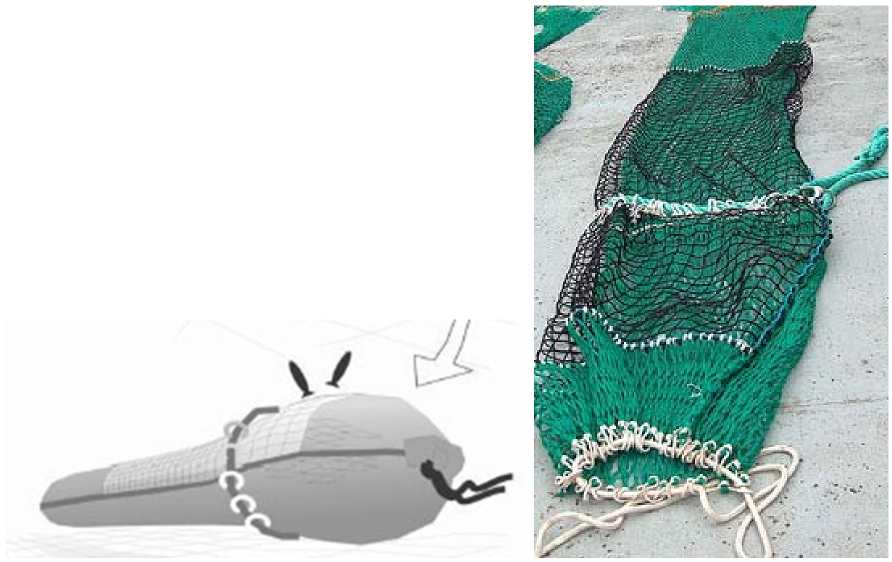


Figure D-3: Illustrations of a BACOMA-like cod end (exit window in the upper panel) and photograph of a BACOMA window.

Application of selectivity on population

To illustrate the effect of changed selectivity on catches of Baltic cod and theoretical discard rates, selected selectivity curves were applied to real population structure. As good estimate for the population structure the length distribution for SD24 (western Baltic Sea) and SD26 (eastern Baltic) were extracted from ICES-DATRAS database (http://datras.ices.dk). Data from the Baltic International Trawl Survey (BITS) 2010 in quarter 1 (February-March 2010) were used. The theoretical catch of all trawls used since 2003 (when MLS=38cm) are illustrated (Figure D-4). Only mean selection curves were applied and between-haul variation, which is potentially significant, was neglected.

The same procedure was used to estimate theoretical discard rates, given as percent in numbers (Table D-1).

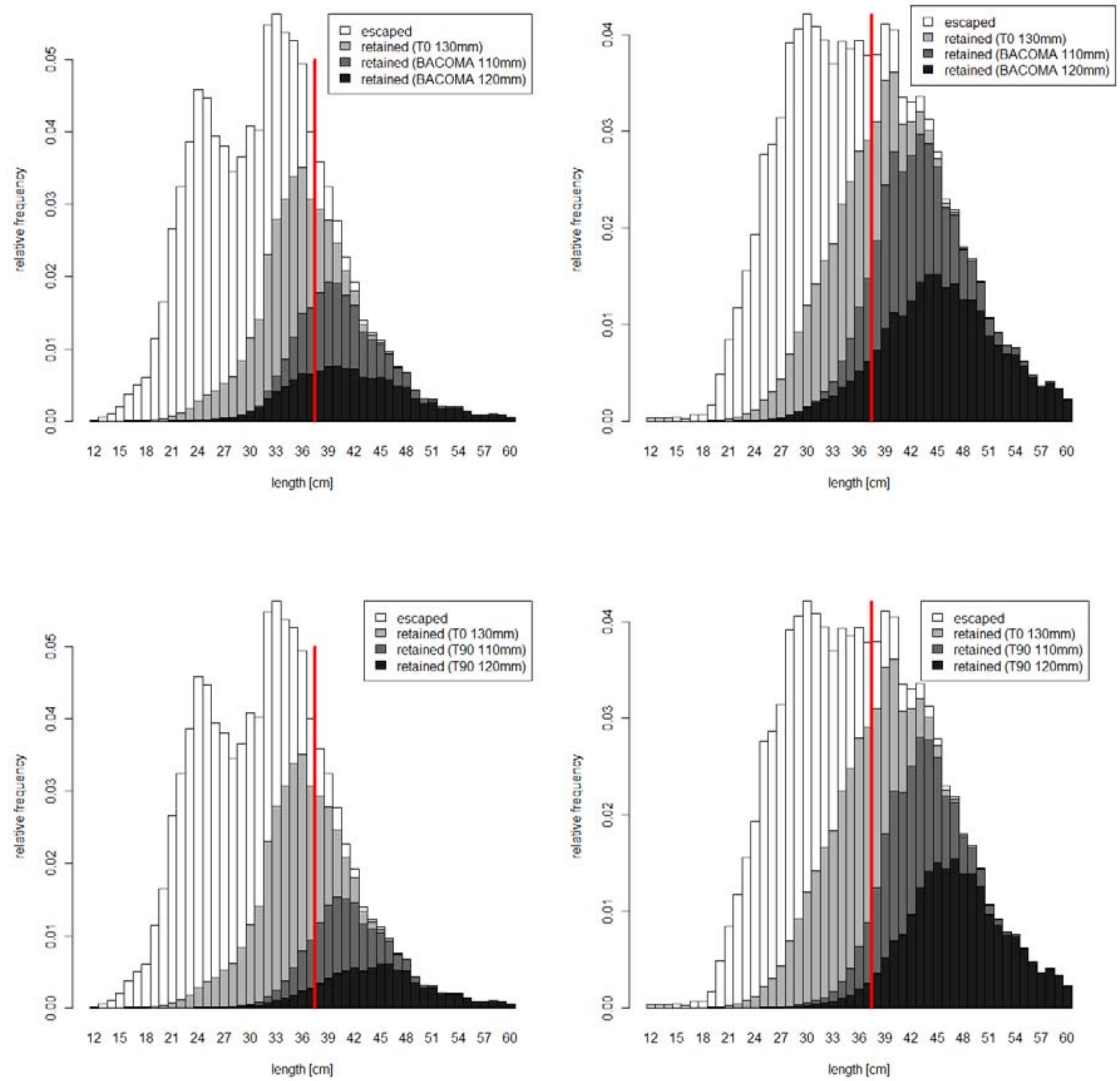


Figure D-4: Selection curves applied on population structure derived from Baltic International Trawl Survey (BITS Q1; data extracted from DATRAS-database http://datras.ices.dk). Top figures: BACOMA-cod ends/T0 130mm; Bottom figures: T90 cod ends/T0 130mm. Left column: ICES SD24 (western Baltic Sea); Right column: ICES SD26 (eastern Baltic Sea).

The changes in gear regulation, applied since 1999, have resulted in a significant reduction in discard proportion (Table D-1). It is important to mention, that the increase in mesh opening for the BACOMA cod ends in 2010 did not resulted in a decrease of discards. The reason is assumed to be the unbalanced selectivity of both nettings used in the BACOMA cod end, as discussed above. In general, the theoretical discard is much lower for T90 cod ends (Figure D-5).

If BACOMA cod end should be a legal option for the next years, it is recommended to increase the mesh size in the lower panel with the aim to harmonize the size selectivity of BACOMA window and T0-part of the cod end. At the moment vTI-OSF and DTU-Aqua conduct experiments and model calculations to make a proper proposal.

In addition to a discard rate, which is not reduced for BACOMA 120mm compared, to BACOMA 110mm, the catch efficiency of both 120mm gears for fish above MLS is significantly reduced. In short term (until the size structure of the population is adopted to the new fishing pattern), this will result in

• increase in fishing effort to catch the same amount of fish (i.e. TAC), resulting in

  - increased fuel consumption (higher climate impact!)

  - increased environmental impact (e.g. bottom contact)

• possible problems to catch TAC within allowed days at sea

• commercial loss for fishermen.

Table D-1: Estimated theoretical discard rates for SD24 and SD26 for different gears. The estimation was done using real population structure extracted from ICES DATRAS database (BITS 2010 Q1).

cod end	SD24	SD26
T0 120mm	60.3%	37.9%
T0 130mm	54.4%	32.3%
Exit window type 1	28.9%	13.5%
BACOMA 120mm (2002)	21.1%	8.2%
BACOMA 110mm	28.5%	13.2%
BACOMA 120mm (2010)	30.7%	12.9%
T90 110mm	17.9%	7.4%
T90 120mm	12.8%	4.3%

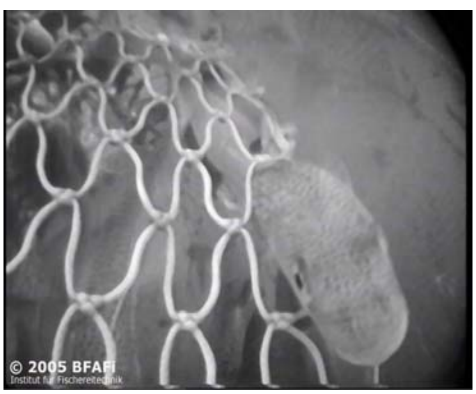


Figure D-5: Underwater observation of fish escaping from a T90-Trawl.

Estimated nominal selectivity properties

As mentioned above, due to practical reasons mesh opening different from nominal mesh openings were used during sea trials. For example, no selectivity data are available for exactly BACOMA 120mm and T90 120mm. If needed, the selectivity at nominal mesh opening can be estimated using regression analysis (Figure D-6 as example). Resulting parameter for BACOMA and T90 trawls are given in Table D-2.

Additionally, Figure D-6 impressively demonstrates the considerable between haul variation (please note different y-axis range).

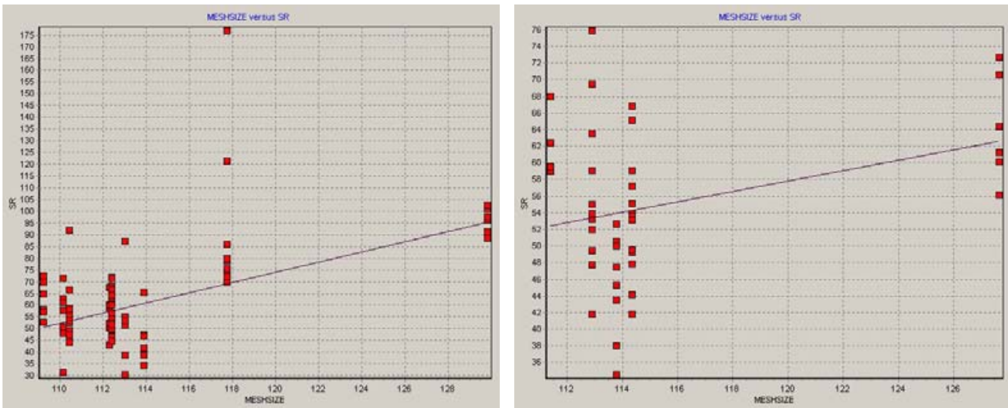


Figure D-6: Estimated selection range for individual hauls at different mesh opening, including regression line. Left: BACOMA cod end; Right: T90 cod end.

Table D-2: estimated theoretical selection parameter at nominal mesh opening

	110mm	120mm
BACOMA	L50: 37.80 SR: 5.24	L50: 41.03 SR: 7.41
T90	L50: 39.75 SR: 5.16	L50: 41.60 SR: 5.78

Future of selectivity as part of technical measures

In this section, two basic scenarios of possible development of selectivity as part of technical measures will be given (in a nutshell).

Scenario 1: no significant change in EU fisheries management

Assuming, that detailed gear regulation and minimum landing size will be a tool for further fisheries management, the selection range and L50 have to be optimized (Figure D-7).

If L50 is close to MLS, broad selection range will result in relatively high discards and commercial short-term losses (grey line in Figure D-7). The solution would be a narrow selection range (red line in Figure D-7).

On the other hand, moving the selection curve to the higher length-classes would result in higher short-term losses, but probably higher long-term yield (Bethke pers. comm).

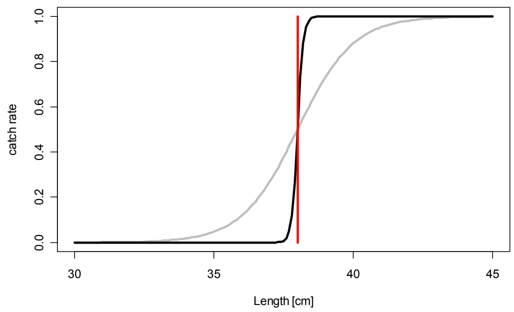


Figure D-7: Illustration of two fictive selection curves and a fictive minimum landing size. Black line: small SR, Grey line: large SR.

Scenario 2: result based management

Many arguments support the introduction of result-based management, including catch quotas, discard ban and simplification of technical regulations. This could also free the creativity of fishermen to develop better fishing gear or choose location and timing of fishing to prevent discards. This creativity is heavily underutilized so far.

Additional information

Table D-3, Table D-5 and Table D-6 summarize relevant technical measures (gear, closures, MLS) for Baltic cod trawl fishery. Names of regulations are also given.

References

Wileman, D., Ferro, R. S. T., Fonteyne, R., Millar, R. B. (editors), 1996. Manual of methods of measuring the selectivity of towed fishing gears. ICES Coop. Res. Rep. No. 215: 126 pp.

Table D-3: Technical measures for the Baltic Sea cod fishery. Overview about legal gears in different years. NA identifies measures, which are not specified in the regulation during this time

		T0 without window			exit window model 1 and model 2								BACOMA window								T90 without window				
					cod end				window				cod end				window								
			max twine thickness			max twine thickness								max twine thickness								max twine thickr			
year	regulation	mesh opening [mm]	single yarn [mm]	double yarn [mm]	mesh opening [mm]	single yarn [mm]	double yarn [mm]	number of meshes around	number windows	mesh opening [mm]	min twine thickness [mm]	length of window	mesh opening [mm]	single yarn [mm]	double yarn [mm]	number of meshes around	number windows	mesh opening [mm]	min twine thickness [mm]	length of window [m]	mesh opening [mm]	single yarn [mm]	double yarn [mm]	number of meshes around	
1999	0088/1998; 0048/1999	120	NA	NA	105	NA	NA	100	2	105	NA	80% of cod end													
2000	0088/1998; 2742/1999	120	NA	NA	105	NA	NA	100	2	105	NA	80% of cod end													
2001	0088/1998; 2848/2000	120	NA	NA	105	NA	NA	100	2	105	NA	80% of cod end	105	NA	NA	100	1	120	4.9	3.5					
2002	0088/1998; 2555/2001; 1811/2002	130	6*	4*									105	NA	NA	100	1	120	4.9	3.5					* specified in 1811/2002, in place 24.09.2002
2003a*	0088/1998; 2341/2002	130	6	4									105	NA	NA	100	1	120	4.9	3.5					*01.01.-31.08.2003
2003b*	0088/1998; 2341/2002; 1754/2003												105	NA	NA	100	1	110	4.9	3.5					*01.09.-31.12.2003
2004	0088/1998; 2287/2003												105	NA	NA	100	1	110	4.9	3.5					
2005	0088/1998; 0027/2005												105	NA	NA	100	1	110	4.9	3.5					
2006	2187/2005; 0052/2006												105	6	4	max. 100	1	110	5	3.5	110	6	4	50	
2007	2187/2005; 1941/2006												105	6	4	max. 100	1	110	5	3.5	110	6	4	50	
2008	2187/2005; 1098/2007; 1404/2007												105	6	4	max. 100	1	110	5	3.5	110	6	4	50	
2009	2187/2005; 1098/2007; 1322/2008												105	6	4	max. 100	1	110	5	3.5	110	6	4	50	
2010	2187/2005; 1098/2007; 1266/2009												105	6	4	max.100	1	120*	6	5.5/6**	120	6	4	50	* SD25-32: from 01.03.2010; * if catch sensor mounted
2011	2187/2005; 1098/2007; 0686/2010												105	6	4	max.100	1	120	6	5.5/6*	120	6	4	50	* if catch sensor mounted

Table D-4: Selectivity properties of legal cod ends in Baltic cod fishery (1999-2010). Investigations from German RV "Solea". Unweighted for the different net types, using the selectivity parameter of individual investigations, neglecting differences like yarn type and twine thickness.

					cod end					window			selection parameter	
Type	nominal mesh opening [mm]	period in use	year	cruise no.	material	meshes around	twine thickness [mm]	yarn	mesh opening mm	meshes around	twine thickness mm	mesh opening mm	L50	SR
T0	120	01/1999-12/2001	04/1999	SO440	PE	100	4	single	118.20				37.71	7.00
			04/1999	SO440	PE	100	4	double	118.00				33.11	7.81
			04/2000	SO457	PE	100	6	double	117.30				24.80	9.45
			09/2001	SO481	PE	100	6	double	117.14				28.77	7.58
								mean	117.66				31.10	7.96
T0	130	01/2002-08/2003	04/2002	SO490	PE	100	6	single	131.09				33.25	7.49
			09/2002	SO497	PE	100	6	single	130.90				30.31	6.33
			04/2002	SO490	PE	100	4	double	131.99				33.84	7.73
			09/2002	SO497	PE	100	4	double	130.90				34.80	7.43
								mean	131.22				33.05	7.25
Exit Window Model 1		01/1999-12/2001	08/1999	SO447	PE	100	NA	NA	NA		4	101.80	37.84	5.23
								mean				101.80	37.84	5.23
BACOMA	120	01/2001-08/2003	09/2002	SO497	PE	50	4	double	(ca. 105)	23	4.9	119.90	43.85	5.92
			04/2003	SO506	PE	50	4	double	102.85	26	4.9	119.60	41.11	7.98
								mean	103.93			119.75	42.48	6.95
BACOMA	110	09/2003-12/2009	04/2003	SO506	PE	50	4	double	113.30	27	4.9	110.40	37.84	5.40
			04/2004	SO522	PE	50	4	double	102.40	27	4.9	108.90	36.98	5.52
			09/2005	SO547	PE	50	4	double	102.40	27	4.9	113.00	37.88	4.88
			09/2007	SO579	PE	50	4	double	106.45	27	4.9	109.76	38.91	5.56
			04/2008	SO586	PE	50	4	double	105.60	27	4.9	112.40	38.71	5.46
								mean	106.03			110.89	38.06	5.36
BACOMA	120	SD22-24: 01/2010 - recent	04/2010	SO619	PE	50	4	double	105.20	19	4.9	129.80	44.25	9.68
		SD25-32: 03/2010 - recent						mean	105.20				44.25	9.68
T90	110	01/2006-12/2009	09/2007	SO579	PE	50	5	single	106.30				41.29	4.65
			04/2005	SO539	PE	50	5	double	109.90				37.85	5.37
			09/2005	SO547	PE	50	4	double	114.23				38.40	3.36
			04/2008	SO586	PE	50	5	single	112.90				39.67	5.54
			04/2008	SO586	PE	50	5	double	109.00				37.84	4.46
			04/2009	SO603	PE	50	5	single	111.40				39.75	3.24
			04/2009	SO603	PE	50	5	single	114.35				39.53	5.71
			09/2009	SO610	PE	50	5	single	114.51				42.02	5.22
								mean	111.57				39.54	4.69
T90 120mm	T90 120mm	SD22-24: 01/2010 - recent	04/2010	SO620	PE	50	5	single	127.65				42.86	6.51
		SD25-32: 03/2010 - recent	09/2010	SO627	PE	50	5	single	128.10				46.20	6.13
								mean	127.88				44.53	6.32

Table D-5: Technical measures for the Baltic Sea cod fishery. Overview about effort limitation applied (closures and days at sea)

		closures						days at sea	
regulation	Article	entire Baltic cod fishery	Bornholm Basin all species	SD22-24 cod fishery	SD25-32 cod fishery	permanent closures defined?	3 defined areas	SD22-24	SD25-32
0088/1998 (technical regulation)						Y			
0048/1999	Art.13.6	01.07.-20.08.1999	15.05.-31.08.1999			Y			
2742/1999	Annex V Art. 2/3	01.07.-20.08.2000	15.05.-31.08.2000			Y			
2848/2000	Annex V	01.07.-20.08.2001	15.05.-31.08.2001			Y			
2555/2001	Annex V	01.06.-31.08.2002	15.05.-31.08.2002			Y			
2341/2002	Annex V Art. 4/5	01.06.-31.08.2003	15.05.-31.08.2003			Y			
2287/2003	Annex VI Art. 4/5	01.06.-31.08.2004	15.05.-31.08.2004			Y			
0027/2005	Annex III part A.4/5			01.03.-30.04.2005	01.05-15.09.2005	Y			
2187/2005 (technical regulation)	Art.16					Y			
0052/2006	Annex II			15.03.-14.05.2006	15.06.-14.09.2006	Y	01.05.-31.10.2006	274	246
1941/2006	Annex II/III			01.01.-07.01.2007 31.03.-01.05.2007 31.12.-31.12.2007	01.01.-07.01.2007 05.04.-10.04.2007 01.07.-31.08.2007 31.12.-31.12.2007	Y	01.05.-31.10.2007	248	222
1098/2007 (management plan)	Art.8/9			01.04.-30.04.XXXX	01.07.-31.08.XXXX	Y	01.05.-31.10.XXXX		
1404/2007	Annex II			01.04.-30.04.2008	01.07.-31.08.2008	Y	based on 1098/2007	223	178
1322/2008	Annex II			01.04.-30.04.2009	01.07.-31.08.2009	Y	based on 1098/2007	201	160
1226/2009	Annex II			01.04.-30.04.2010	01.07.-31.08.2010	Y	based on 1098/2007	181	160
XXXX/2010 (proposal)	Annex II			01.04.-30.04.2010	01.07.-31.08.2010	Y	based on 1098/2007	163	160

Table D-6: Technical measures for the Baltic Sea cod fishery. Specification of Minimum Landing Size (MLS) for cod.

regulation	Article	start date	MLS [cm]
88/1998	Annex III	01.01.1998	35
2341/2002	Annex V Art. 3	01.01.2003	38
2287/2003	Annex IV, Art.3	01.01.2004	38
0027/2005	Annex III partA.3	01.01.2005	38
2187/2005	Annex IV	01.01.2006	38

Annex E: Effects of recreational fisheries on cod stocks in the western Baltic – selected results of the German recreational fishery

Preface

Recreational fisheries sampling started in Europe with the introduction of the Commission Regulation (EC) No 1639/2001 requiring Member Sates (MS) to sample Bluefin tuna catches in all areas and Salmon in marine waters of the North and Baltic Sea. With the amendment of this regulation through Commission Regulation (EC) No 1581/2004 the recreational species listed in Appendix XI was expanded to also contain cod (Gadus morhua) in areas III, IV, V, VI and VII (given that cod was the subject of recovery plans in these areas). MS were required to conduct pilot surveys to establish the basis for future requirements. The conclusions of these surveys had to be forwarded to the Commission by 31 March 2007.

The German pilot study revealed that significant recreational fishery catches were only relevant for cod in the Baltic Sea in particular in SD 22 + 24. Between 2004 and 2006 a total of 67 000 questionnaires were distributed of which 2267 were evaluated. During on-site surveys 351 beaches and ports along the German Baltic coast were sampled and 3 890 anglers interviewed. To estimate the length distribution of cod catches nearly 15 000 species were measured during 146 fishing tournaments. To estimate catches of the recreational fishery fishing with commercial fishing gear 10% of the 181 registered recreational fishermen were questioned. The total cod biomass removed by the recreational fishery amounted to between 1 900 and 3 600 t in 2004, between 2 750 and 5 100 t in 2005 and between 1 900 and 3 100 t in 2006.

In Sweden the total catch of cod was estimated to be around 1 150 t in 2004. The Danish study from 2006 estimated a catch of 645 t of cod limiting the study area to the Sound. The following table gives an overview of the estimated recreational cod catches from EU Member States in the Baltic Sea.

Table E.1 Estimates of cod catches by recreational fishers from the Baltic in different years

Country	Year	Recreational Fishery Cod Catch
Denmark	2006	645 t
Sweden	2004	1 150 t
Lithuania	2005	28 t
	2006	36 t
Poland	2005	225 t
Germany	2004	1 900 – 3 600 t
	2005	2 750 – 5 100 t
	2006	1 900 – 3 100 t

According to the findings from these pilot studies recreational fishery sampling was continued and expanded to other species ((EC) No 949/2008). Consequently MS have been increasing efforts conducting new and revised pilot studies. In particular this were the eel and cod catches in Danish recreational fishing (DTU Aqua report no. 217-2010). Thereby Denmark confirms their cod catch estimates expanding the study area to the entire western Baltic (SD 22 – 24). In conclusion, it is argued that the majority of recreational fishery cod catches in the Baltic Sea occur in SD 22 - 24 thus targeting western Baltic cod.

Introduction

As required by Council Regulation (EC) No 949/2008 Member States are required to estimate annual recreational fisheries catches of cod, salmon and eel in the Baltic Sea, further Council Regulation (EC) No 1224/2009 states that:

> *For stocks under a recovery plan Member States should collect catch data of recreational fisheries. Where such fisheries have a significant impact on the resources, the Council should have the possibility to decide on specific management measures.*

Germany has been collecting recreational fishery data since 2004 annually. Pilot studies in Germany revealed that significant recreational fishery catches are only relevant for cod in the Baltic Sea in particular in SD 22 + 24. Corresponding to the decline of the western Baltic cod stock and the subsequent quota reductions of the commercial fishery in recent years recreational fishery catches have gained importance.

A recent meeting of a Baltic subgroup of the ICES PGRFS (Planning Group on Recreational Fishery Surveys) investigated the potential to include recreational fisheries catch data in the stock assessment for the western Baltic cod stock by means of establishing a common tuning fleet in the western Baltic, by setting up panels of fishermen and/or fishing vessels.

Selected results of the German recreational fishery in 2009

The majority of **recreational fishery cod catches in SD 22 + 24** are from anglers using line and rod and come from the following categories (ranked according to their importance):

1. Cutter angling (129 “angling cutters” are registered in Germany)
2. Boat fishing (private vessels)
3. Shore fishing
4. Trolling
5. Wading

Sampling

To estimate the mean effort of anglers in 2009 (angling days/year) the results from the mail surveys 2004-2006 were used (pilot study). This data was augmented with the actual number of members in the angling associations in Mecklenburg Western Pomerania (MV) and Schleswig Holstein (SH), the number of fishery licenses sold in MV and SH and the annual numbers of angling licenses sold for the coastal waters of MV.

To estimate the catch per unit effort a total of 283 samples were realized in 2009. Thereby 49 samples were carried out targeting shore fishing activities interviewing 223 anglers and 234 samples were realized targeting boat and vessel angling yielding 2 069 interviews.

Fishing method	Samples	Interviews
Cutter angling	147	1 694
Boat fishing	204	346
Trolling	204	18
Shore fishing	49	172
Wading	49	51
Total	**653**	**2 281**

The following table gives an overview of the sampling in 2009 to estimate the length composition of landings from beach fishing and boat/cutter angling.

	Samples	**No. of measured cod (retained)**	**No. of measured cod (released)**
Charter vessel trips with observer	41	1 239	766
Boat- self-measurement	24	100	117
Trolling - self-measurement	12	45	1
Shore fishing – fishing events	3	3	10
Total	**80**	**1 387**	**894**

Effort

In 2009 a minimum (precise data) of 119 500 respectively 155 000 anglers maximum (recollected data) went fishing in the Baltic Sea. The total effort in the Baltic Sea in 2009 was estimated between 938 595 and 1 614 490 angling days.

The following table provides an overview of the estimated effort for the different fishing types, bi-annual and in total.

	Minimum			Maximum		
Type	1. Half year	2. Half year	Total	1. Half year	2. Half year	Total
Shore fishing	116 695	198 280	314 975	223 277	322 160	545 437
Boat fishing	121 581	183 663	305 244	249 188	287 093	536 281
Cutter angling	80 789	90 196	170 985	108 596	109 976	218 573
Wading	118 753	11 153	129 906	170 473	120 076	290 549
Trolling	8 431	9 053	17 485	11 941	11 708	23 650
Total	**446 250**	**492 345**	**938 595**	**763 477**	**851 013**	**1 614 490**

The catch per unit effort (CPUE) – based on on-site surveys in 2009 – was calculated for the different fishing categories and was the highest for the boat/cutter fishing and the lowest for wading.

	CPUE (catch/day) in numbers		
Type	**Cod (landed)**	**Cod (released)**	**Total**
Cutter angling	2.6	2.0	2.3
Boat fishing	2.3	1.6	2.0
Trolling	1.8	0.8	1.3
Shore fishing	0.6	3.5	2.1
Wading	0.1	0.1	0.1
Total	**2.5**	**1.6**	**2.1**

Catches in numbers

The following table shows the cod catches (numbers) of the German recreational fishery in 2009, divided into released and landed cod, according to the applied fishing method, bi-annual and in total.

		Minimum			Maximum		
	Type	1. Half year	2. Half year	Total	1. Half year	2. Half year	Total
Released cod	Shore fishing	126 302	1 033 988	1 160 289	267 602	1 605 640	1 873 241
	Boat fishing	214 251	325 299	539 550	435 684	501 060	936 744
	Cutter angling	106 223	170 009	276 233	149 448	220 775	370 222
	Wading	5 822	3 718	9 540	9 847	28 648	38 495
	Trolling	8 493	0	8 493	13 197	0	13 197
	Total	**461 091**	**1 533 014**	**1 994 105**	**875 777**	**2 356 123**	**3 231 900**
Landed cod	Cutter angling	210 567	468 516	679 083	252 308	516 914	769 222
	Boat fishing	228 629	343 983	572 612	474 754	558 264	1 033 018
	Shore fishing	37 363	145 585	182 948	63 591	236 866	300 457
	Trolling	15 022	5 388	20 410	24 417	8 025	32 441
	Wading	0	11 153	11 153	0	17 682	17 682
	Total	**491 581**	**974 625**	**1 466 207**	**815 069**	**1 337 751**	**2 152 820**
Total total				**3 460 312**			**5 384 720**

Catches in weight

In 2009 a minimum of 2 233 t respectively 3 387 t of cod maximum were landed in the German recreational fishery in the Baltic Sea (SD 22 + 24).

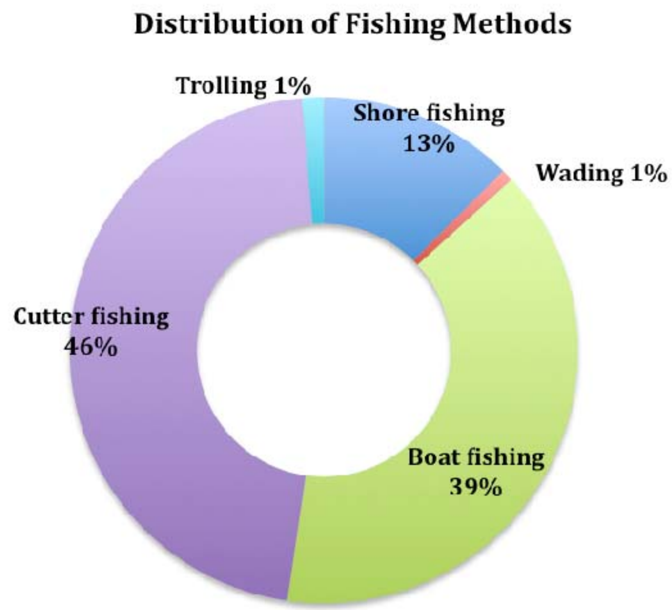
The following table shows the cod catches of recreational fishing in tons in 2009, divided into released and landed cod, according to the applied fishing method, bi-annual and in total.

		Minimum			**Maximum**		
	Type	1. Half year	2. Half year	Total	1. Half year	2. Half year	Total
Released cod	Shore fishing	23	297	320	50	461	510
	Boat fishing	40	93	133	81	144	224
	Cutter angling	20	49	68	28	63	91
	Wading	1	1	2	2	8	10
	Trolling	2	0	2	2	0	2
	Total	**85**	**440**	**525**	**162**	**676**	**838**
Landed cod	Cutter angling	323	718	1 041	387	801	1 187
	Boat fishing	350	527	878	728	865	1 592
	Shore fishing	54	212	267	93	433	525
	Trolling	23	8	31	37	12	50
	Wading	0	16	16	0	32	32
	Total	**751**	**1 482**	**2 233**	**1 245**	**2 143**	**3 387**
Total total				**2 758**			**4 226**

Distribution of Fishing Methods

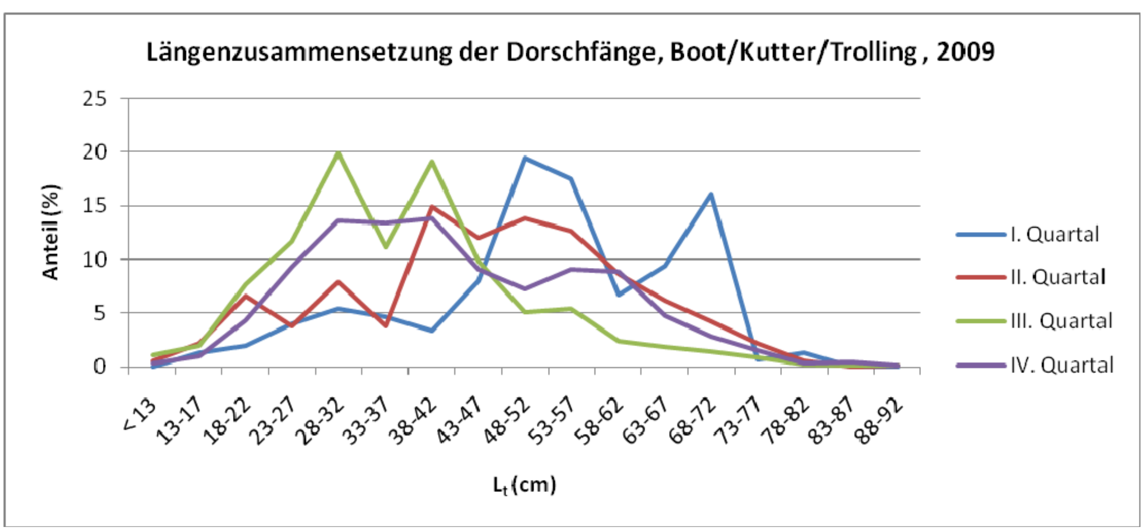
85 % of the cod catches are from boats and cutters. Commercial charter vessels “fishing cutters” offer daily fishing trips from ports on the German Baltic coast. Fishing trips usually cost between 30 and 50 Euro per person. According to the vessel size they can take up to 50 persons per trip.

The majority of boat fishing is carried out from privately owned boats. However, in many harbors small boats can be rented for fishing. The following diagram gives an overview of the distribution of fishing methods according to their cod catches.



Seasonality/Trends

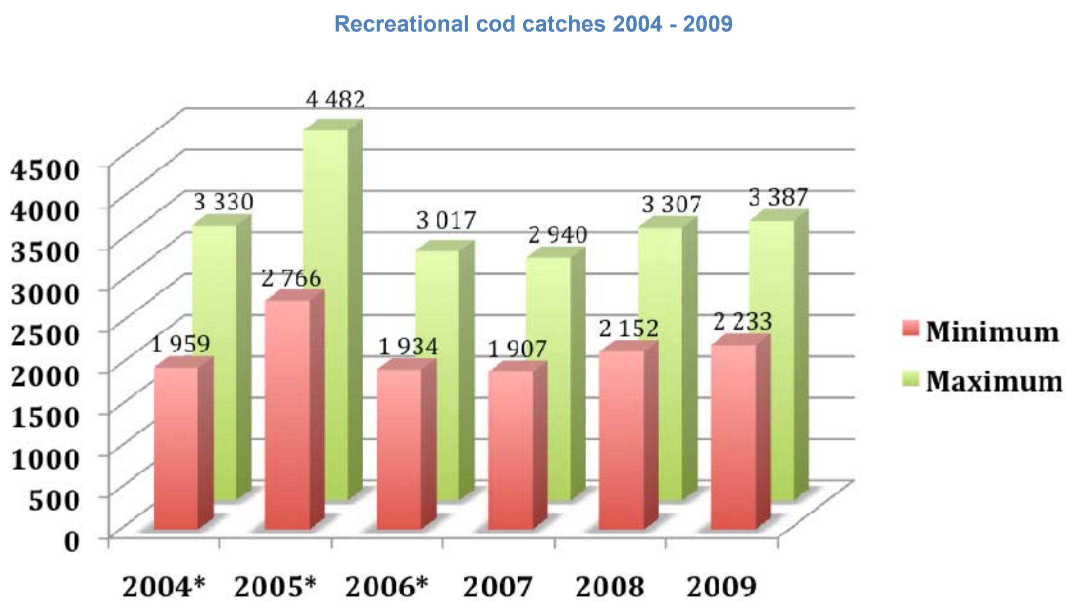
The following diagram gives an overview of the length distribution of cod catches per quarter (cutter fishing, boat fishing and trolling) in 2009. According to this the majority of smaller cod were caught in the summer months, whereby larger cod were caught from January until April.



The following table gives an overview of the average size of cod caught in the recreational fishery in 2009.

	I. Quarter	II. Quarter	III. Quarter	IV. Quarter
Cod (landed)	57.7	53	48.3	53.1
Cod (released)	28.5	26.3	28.2	29.4

Based on the recreational fisheries survey data and the estimation method annual German cod catches in the Baltic Sea (SD 22 + 24) varied between 1 907 t in 2007 and 2 766 t in 2005 based on recorded effort data from diaries. Using effort data based on estimates from anglers annual catches varied between 2 940 t in 2007 and 4 482 t in 2005.



* Please note that yearly landings in the years 2004 - 2006 were calculated by means of average masses of the cod commercially caught in SD 22 + 24 and the length distribution of landings of the anglers using a general length-mass relationship. Since 2007 calculations are based on the recorded length distribution of angler landings and the length-mass relationship from the German commercial fishery (from the active commercial fishery for boat, cutter and trolling & from the passive commercial fishery for surf fishing and wading).

Data quality

An analysis of the calculated landing data (2009) by means of bootstrapping estimated a relative deviation between 13 % as minimum and 24 % as maximum for the different estimated numbers of landings (see table below).

		Confidence intervals (α = 0,025)	
	Landings (numbers)	2,5 % Percentile	97,5 % Percentile
Recorded effort-data, Jan - Jun	491 581	413 091	588 158
Recorded effort-data, Aug - Dec	974 625	845 867	1 107 919
Estimated effort-data, Jan - Jun	815 069	655 915	1 008 842
Estimated effort-data, Aug - Dec	1 337 751	1 101 987	1 594 772

Discussion

Recreational fisheries remove considerable amounts of cod from the western Baltic cod stock. Exemplary, estimated cod catches in SD 22 - 24 in 2009 varied between 2 200 - 3 400 t in Germany, 600 t in Denmark and approximately 500 t in Sweden. The effect of this is twofold:

1. Currently unaccounted fishing mortality (F-Recreational)
2. Underestimation of stock productivity (SSB)

In comparison to the German commercial fishery in SD 22 + 24 in 2009 (4 020 t) recreational fishery landings of western Baltic cod amounted to 56% respectively 84% of the commercial fishery landings. In contrast to the commercial fishery with total annual catch limitations unlimited recreational fishery catches vary annually by several hundred tons.

Release of undersized cod (< 38 cm) is relative high but release and discards are not the same, since the mortality rate of released cod caught in the recreational fishery is believed to be relatively low. An anticipated pilot project is planned to estimate mortality rates of released cod – dependent on the fishing technique applied (lures, natural bait) – in order to specify future use of released cod data.

A recent discussion during the ICES-PGRFS Baltic meeting from 16-17 September 2010 in Charlottenlund, Denmark with representatives from Denmark, Sweden and Germany came to the conclusion that the stock assessment could benefit substantially by using the independent recreational fishery survey data as a tuning fleet to improve the classification of age group, recruitment trends and other population parameters. This would have no further management implications.

In light of the current evaluation of the multiannual management plan for the cod stocks in the Baltic the tuning fleet approach misses to address the two points mentioned above adequately. The main objective of the multiannual management plan is the specification of a target fishing mortality rates of 0.6 (ages 3 to 6 years) in ICES SD 22 – 24 (Council Regulation (EC) No 1098/2007). However, this target fishing mortality rate (F-target) only refers to the fishing mortality caused by the commercial fishery (F-commercial) and does not include recreational fisheries. Consequently, a different approach would be to aims at including recreational fishery catches in the western Baltic cod stock assessment stratified in age groups according to the length distributions acquired in the on-site recreational fishery survey. This approach would allow estimating the fishing mortality by recreational fishing (F-recreational). In a next step, F-recreational could be subtracted from the current F-target to calculate a new target fishing mortality rate (F-target new) for a new and revised multiannual management plan.

The question of how to handle a new and possibly higher calculated SBB using the data from the recreational fishery as described above requires thoughtful thinking and discussion, since this could have considerable impacts on the ICES advice. One needs to be aware that higher TACs due to a higher stock productivity raise the question of how to distribute TACs between MS. To safeguard against this, recreational fishery landings could be subtracted from the total TAC. It should be noted that the introduction of a new TAC for the recreational fishery is pointless, since the monitoring efforts required to estimate the stock removal of the recreational fishery are too high.

Despite the discussion, if the closed period in ICES SD 22 – 24 from the 1st until the 30th of April covers the spawning period of the western Baltic cod or not, it should be mentioned that no seasonal closure for cod exists within the German recreational fishery. This circumstance is also the impetus for disputes within the German recreational fishing community weather to introduce a closed season during spawning. An evaluation of the multiannual management plan should explore the possibilities to expand the closed periods covering both the commercial and the recreational fishery.

ANNEX F: RECENT CHANGES IN THE EASTERN BALTIC COD STOCK AND THE DRIVERS OF THESE DEVELOPMENTS

Spawning stock biomass of the Eastern Baltic cod increased more than four-fold during 2005-2010 and the fishing mortality simultaneously declined to below the management target of 0.3. The increase in SSB was largely due to increased recruitment. The decline in fishing mortality was due to a combination of reduced catch and increased recruitment, whereas a change in selection pattern contributed to the decline in Fbar (average of age 4-7) as well. Catch reduction in the Eastern Baltic cod in 2007-2008 was mainly due to a reduced proportion of illegal landings. The reduction in TAC in 2007 and 2008 alone had only a minor influence on stock development. The harvest control rules of the management plan kept the TAC in 2009 at a much lower level than would have been the case at previous precautionary approach. This allows the stock to accumulate larger biomass and thereby facilitate rebuilding of the stock.

Recent changes in parameters influencing the stock

Recent changes both in fisheries removals from the stock and in the strength of incoming year-classes have been favourable for the development of the Eastern Baltic cod. Total catch in 2007-2008 was 20-30% lower compared to the level in previous years (2002-2006), with some increase in 2009. The major part of the reduction in total catch was due to improved compliance with TAC (Figure F1). In 2004-2006, ICES estimated total landings to be about 30% higher than the TAC. The amount of estimated illegal landings was reduced by half in 2007, and since 2008 ICES considers the total landings not to have exceeded the TAC.

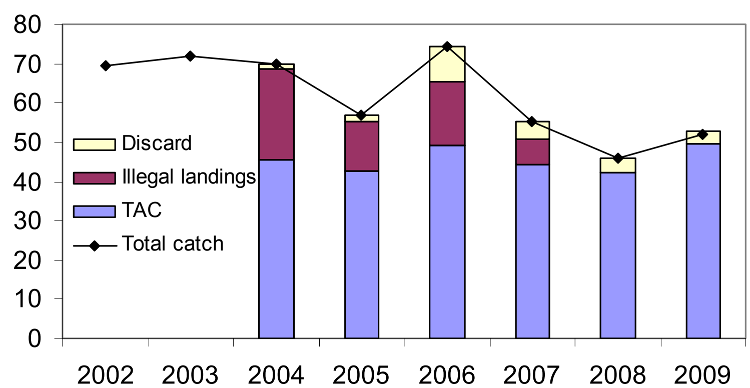


Figure F1. Total catch (thousand tons) of the Eastern Baltic cod, broken down to landings corresponding to TAC, discards and illegal landings (TAC overshoot).

Recruitment (age 2) in each year since 2005 has been 20-50% higher compared to 2002-2004 (Figure F2).

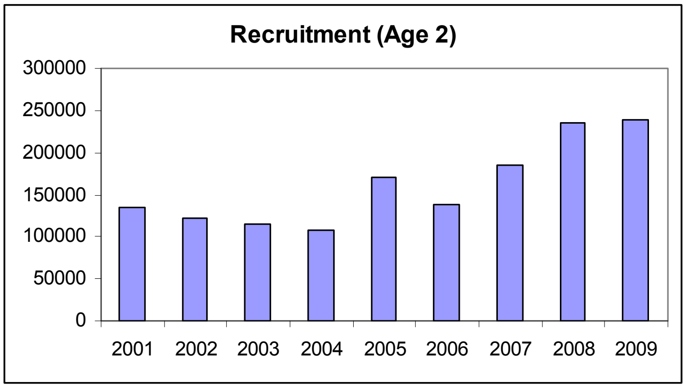


Figure F2. Number of recruits (age 2) of the Eastern Baltic cod.

Selection at age in fisheries has also changed in recent years (Figure F3). In 2004-2005, selection continuously increased with age, levelling off at age 5. This pattern started to change in 2006, when relative fishing mortality on age 3 became higher than in previous years. In 2007-2009, fishing mortality was highest for age groups 4-5, and relatively lower for older ages. This pattern could be due to several incoming stronger year-classes, which have been selected relatively more that the older ages originating from earlier poor year-classes.

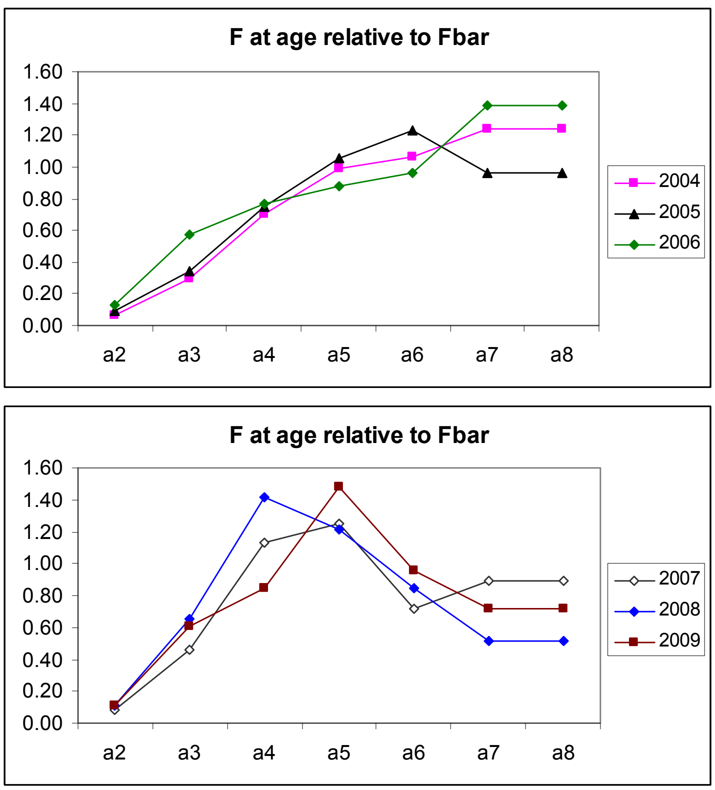


Figure F3. Changes in selection pattern (F at age relative to Fbar) of the Eastern Baltic cod in 2004-2009.

Effects of changes in catch, recruitment and selection on F and SSB

Recent developments in SSB and fishing mortality of Eastern Baltic cod were considered potentially influenced by changes in i) total catch, ii) recruitment, and iii) selection pattern. Additionally, variations in iv) mean weight at age were considered. In order to analyse relative contributions of changes in these parameters to the observed stock trends, stock projections were conducted where recent changes in these parameters were "turned off".

First, the effect of a change in each parameter was investigated separately, by setting the values for a parameter in consideration to previously observed level (before a recent change in a given parameter took place), while keeping the rest of the parameters as observed.

1a: - Total catch (in weight) in 2007-2009 was set to the average level observed in 2002- 2006 (68 kt).

1b: - Selection pattern (relative F at age) in 2006-2009 was set to the average observed in 2003-2005.

1c: - Recruitment (age 2) for each year in 2005-2009 was set to the average level observed in 2000-2004 (130 millions).

1d: - Weight at age, both in the catch and in the stock in 2005-2009 was set to the average observed in 2002-2004.

The results of these analyses (Figure F4) show that the observed decline in fishing mortality since 2005 was not due to one single factor but a combination of different variables; a substantial decline in F was still achieved even if one of the four parameters in consideration was kept constant at previous level. Concerning SSB, the effect of recruitment is more outstanding, being a major driver for the observed stock increase.

Recent changes in all four parameters (total catch, recruitment, selection pattern, weight at age) had some effect on the decline in Fbar and/or increase in SSB in recent years. All projections, keeping one of the parameters constant at previous level, resulted in higher fishing mortality and/or lower SSB for some years than observed. However, largest effects on the developments in SSB and F had the increased recruitment and reduction in total catch. Recruitment had clearly the largest effect on SSB, whereas both the declined catch and increased recruitment had similar effects on fishing mortality. Applying the average recruitment as observed in previous years resulted in 40-50% lower SSB in 2009-2010 compared to the estimates from the latest assessment, whereas applying total catch at previous average level resulted in about 20% lower SSB in 2009-2010. Both scenarios, either with previous high catch or previous relatively lower recruitment, resulted in fishing mortality in 2009 at around 0.4 (above the target; Figure F4).

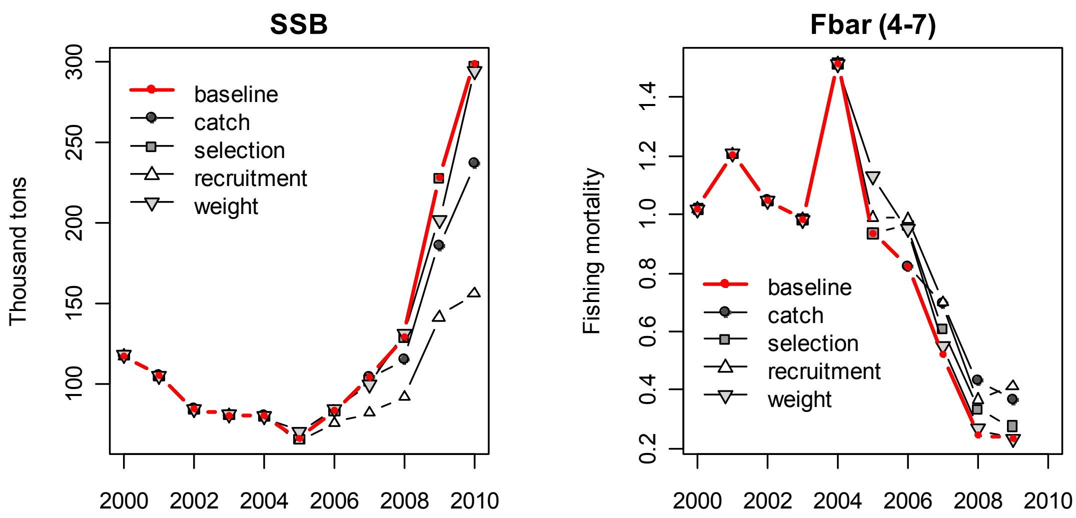


Figure F4. SSB and fishing mortality of the Eastern Baltic cod from stock projections where one of the four parameters , i.e. total catch, selection pattern, recruitment, weight at age (shown in the legend) was set to an average level observed in earlier years, keeping the rest as observed. Baseline refers to SSB and F as estimated from the latest assessment.

In a next step, cumulative effects of the four investigated parameters on SSB and fishing mortality are shown. To do so, the stock projections were structured followingly:

2a: all parameters in consideration were set to an average level of earlier years

- Recruitment (age 2) for each year in 2005-2009 was set to an average level observed in 2000-2004 (130 millions).
- Weight at age, both in the catch and in the stock in 2005-2009 were set to average observed in 2002-2004.
- Selection pattern (relative F at age) in 2006-2009 was set to average observed in 2003-2005.
- Total catch (in weight) in 2007-2009 was set to average level observed in 2002-2006 (68 kt)

2b: - Recruitment as observed

- Weight, selection and catch kept as in 2a

2c: - Recuitment ,weight at age (both in catch and in stock) as observed

- Selection and catch kept as in 2a

2d: - Recuitment ,weight at age (both in catch and in stock), selection pattern as observed

- Catch kept as in 2a

2e (observed): Recruitment, weight at age, selection and catch at observed levels, corresponding to observed developments in SSB and F.

Keeping all four investigated parameters constant at previous level (2a) resulted in continuously low SSB (about 30% of the observed) and fishing mortality at previous high level (above 1). Setting only recruitment to observed values generated 50-70% of the observed SSB in 2009-2010, and a reduction in fishing mortality to 0.45 in 2009 (Figure F5). Variations in weight at age contributed to the decline in fishing mortality in 2005-2006 and to the increase in SSB in 2009. Adding the effect of a change in selection pattern reduced the fishing mortality (Fbar) by 18%, resulting in Fbar at 0.36 in 2009. Reduction in catch further reduced the fishing mortality by 35% (resulting in the observed level) and contributed about 20% of the observed SSB in 2009-2010 (Figure F5).

ANNEX G: POTENTIAL INFLUENCE OF MIGRATION ON WESTERN BALTIC COD ASSESSMENT

The effects of migration is dealt with in three sections, the first deals with an analysis of survey data (Annex G Pt1), the second evidence from catches (Annex G Pt2) and the third presents a preliminary evaluation of the effect of our best (but poor) estimate of the extent of migration on the management advice though simulation (Annex G Pt3). We recognise that if revisions to the management plan are to be considered this work may need to be revisited.

ANNEX G: PT.1 EVALUATION OF MIXING OF BOTH BALTIC COD STOCKS FROM SURVEY DATA

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Introduction

In fisheries management a stock is an idealized fundamental unit which, when correctly identified, allows estimation of important population parameters without the biases that result from incorporation of unknown components of additional unit stocks (Waldman, 2005). Fish stock identification is thus the prerequisite for any fishery analysis, including the broad fields of stock assessment, population dynamics and conservation. Stock discreteness is, however, often assumed without implementing stock identification requirements such as life history traits, morphology, environmental signals and genetics (Cadrin et al., 2005), which together eventually determine the specific reaction of a stock to exploitation (Hammer and Zimmermann, 2005). Consequently, an inherent level of uncertainty concerning the actual stock structure generally prevails (Begg and Waldman 1999, Cadrin and Friedland 1999), especially in relatively mobile species such as cod (Aro, 1989, 2000; Neuenfeldt et al., 2007), in which individuals of various stocks may mix at certain times at certain places to a certain degree, yet maintain their reproductive discreteness (Campana et al., 1999).

The understanding of the population structure of an exploited fish species is a prerequisite to a proper management of the fishery (Carvalho and Hauser 1994; Ruzzante et al. 1996) especially if intensive spatial mixing of stocks occurs with different reproduction characteristics like Baltic cod. Neglecting the existence of a largely varying mixture of different stocks of a species in the catch can lead to an over-exploitation of less reproductive populations and, on the long run, to an erosion of the genetic resources by depleting whole spawning components (Allendorf et al., 1987; Carvalho and Hauser, 1994; Ruzzante et al., 1996).

At present, cod (*Gadus morhua*) in the Baltic Sea is separately managed as a western stock and an eastern stock, inhabiting ICES subdivisions 22−24 and 25−32, respectively (Fig G:1, Oeberst, 2001). The western stock spawns mainly in the Belt Sea and with lower intensity in the Arkona Sea in spring (Bleil and Oeberst, 2002; Bleil et al., 2009); peak spawning of the eastern stock is presently observed in the Bornholm Sea and more east areas in summer (Kändler 1944; Bagge et al., 1994; Wieland et al., 2000; MacKenzie et al. 2000; Karasiova et al. 2008; Bleil et al., 2009) as well as in the Arkona Sea (Bleil et al., 2009). Studies by Borje et al. (1985) on maturity of cod in the Kattegat (SD 21) indicated that spawning in this area begins even earlier.

The two stocks have been separated by means of meristic and morphometric characteristics (Berner, 1968; Birjukov, 1969; Bagge and Steffensen, 1980; Berner and Müller 1989, 1990). Tagging experiments also indicated two separate stocks with limited overlap around the island of

Bornholm (Aro, 1989; Bagge et al., 1994). Furthermore, was shown that cod carries out intensive migration between the feeding areas in the shallow waters and the spawning grounds in the deepest parts of the ICES subdivisions (Bagge et al. 1994, Aro 2000). Another distinguishing feature is the salinity requirement for successful fertilization and the buoyancy of eggs: Spermatozoa of western cod are inactive below 15 psu, whereas sperm motility of eastern cod is sufficient above 11 psu (Westin and Nissling, 1991). Eggs of western cod and eastern cod are neutrally buoyant at 20 psu and 14.5 psu, respectively (Nissling et al., 1997). Even though mixing does occur, genetic investigations like electrophoretic mobility patterns of haemoglobin (Jamieson and Otterlind 1971; Sick 1965), expression of various enzymes such as transferrin (Jamieson and Otterlind 1971), lactate-dehydrogenase, isocitrate-dehydrogenase, phosphogluco-isomerase (Moth-Poulsen 1982) and microsatellites (Nielsen et al., 2003) confirmed the existence of two discrete Baltic cod stocks. Based on this multiple evidence, the two stocks have been assessed separately since 1970, but were not managed separately until 2005. Individuals are assigned to one of the stocks by the location of the catch and independent on biological information.

Only one characteristic exist which can be easily used to separate Baltic cod into different components. The different spawning periods result in bimodal length distribution of year-class which can be used to assign defined length ranges to spawner types (spring spawned cod and summer spawned cod) with high probability. However, the spawner types do not correspond with the used stock units (western and eastern Baltic cod). Spring spawned cod were mainly spawned in ICES SD 22 and SD 24. Only single spanwing individuals were also observed in SD 25 in spring. Summer spawned cod were mainly spawned in ICES SD 24 and east of Bornholm (ICES SD 22 – 28). In some years single spawning individuals were also captured in SD 22. Both spawner types can be spawned in SD 24, but SD 24 is more important for summer spawned cod (Bleil et al. 2009). Therefore, the analyses of the mixing of cod in the Baltic Sea based on length frequencies present only the distribution patterns of spawner types and not the distribution patterns of the western and eastern Baltic cod stock.

Analyses of cod otolith microstructure show that the length distribution in juveniles from both spawning areas is nearly normally distributed (Oeberst and Böttcher, 1998), and juveniles from the two spawning areas differ by 3 to 5 cm in mean length, due to the differences in spawning season. These differences of the length distribution were already applied to identify spawner types (spring or summer spawners) in the length frequency of cod (Oeberst, 2001) estimated based on trawl surveys in the Baltic Sea who showed that in ICES SD 25 15% to 45% of the cod aged 2 or 3 years, and 10% to 90% of the 1 year-olds captured in February were spawned in the Belt Sea. Contributions supporting the occurrence of spring spawned cod in ICES SD 25 came from the analyses of the micro-structure of the Sagitta otolith (Oeberst and Böttcher, 1998), counts of the dorsal fin rays (Müller, 2002), wind driven transport of pelagic stages (Hinrichsen et al., 2001). Nielsen et al. (2003) have shown that cod in the Belt Sea is closely related to the North Sea cod and found the largest leap in the level of differentiation in the samples occurring between the Belt Sea and Arkona Sea and attributed the majority of the samples from the Arkona Sea to the Eastern Baltic cod stock based on micro-satellite markers.

First trawl surveys have been carried out in the Baltic Sea by Poland since 1976. Other countries established own national surveys some years later using different national gears and different periods within the quarter 1 (Q1) and 4 (Q4). The coverage of the Baltic Sea was significantly higher during the surveys in quarter 1. Internationally coordinated Baltic International Trawl Survey (BITS) was established in 2001 which were coordinated by the ICES working group “Baltic International Fish Survey” (WGBIFS). BITS covers the ICES subdivision 22 to 28 the main distribution area of cod in the Baltic Sea with fixed number of stations within SD 23 (3 hauls) and SD 27 (10 hauls). All participating countries used standardized gear types TV3 #930 (TVL) or TV3 #520 (TVS) during the surveys in quarter 1 and 4. The trawls are described in the BITS manual (ICES, 2010). The mesh size of cod end with i = 20 mm corresponds with $L_{50} \sim 6$ cm and $L_{75} \sim 9$ cm. The horizontal net opening of the large TV is 1.54 times larger than the horizontal net opening of the small TV. The version of TV is used by country dependent on the vessel size. To minimize the different catchability of both versions it was agreed that TVL is used only in SD 25 – 28 (Tab. 1). Conversion factors which are estimated for 5 cm length intervals are used to transfer catch per hour of small TV in units of large TV. The conversion factors significantly differ from the relation between the horizontal net opening of the large and small TV in the most length intervals (Fig G:2).

The main target species of the surveys is cod and flounder, but, all other flatfishes were also recorded according to the manual of the BITS (ICES 2008). The total number of planned stations is allocated to the ICES subdivisions and depth layers according to agreed procedure (ICES 2008). The area of depth layers which were used as weighting factors to calculate stratified means are also given in the BITS manual. The data of the BITS are used as fisheries independent stock indices. Data of BITS are stored in the DATRAS database which is hosted by the ICES. The database contains different tools for estimating stock indices of different aggregation levels. Source data can be can be downloaded from DATRAS system.

The aim of the study is the description of the spatial distribution of spring and summer spawning cod in the total Baltic Sea based on the BITS in spring and November where length intervals were used to identity age groups of spring and summer spawners.

Materials and Methods

Data of BITS from 2002 onwards were used in the study to avoid possible effects of different gear types and different survey designs used in the years before. The number of total stations differed between quarter 1 and 4 surveys differed (Tab. 2). Low numbers of stations were realized in 2002 because experiments were carried out to compare the catchability of the new standard gears with the former used national gear. Not include are the stations which were carried out by RV Havfisken in quarter 4 2009 and quarter 1 2010. The numbers of hauls were significantly lower during the surveys in quarter 4. Data in exchange format from DATRAS database were used to describe the horizontal distributions of cod in the Baltic Sea by means of catch per hour of single stations by length class.

Sampling periods are defined in the BITS manual with 15 February to 31 March for quarter 1 and 1 to 30 November for quarter 4. Periods of 15 to 30 days are possible between the sampling of different countries in the same ICES subdivision. Minimum number of samples for age readings and estimation of sex ratio as well as maturity stages are required for length classes with more than 5 % of total catch in number (ICES 2010a). Five maturity stages are defined in DATRAS which are described in the BITS manual. Tables which describe the transfer of national coding into the DATRAS code are also given. The development from the beginning of maturation until spawning takes about 4 month. Therefore, individuals occur during quarter 1 BITS which are shortly before spawning or started the maturation. Both stages of maturity development are coded in one maturity stage in DATRAS.

Conversion factors between the large and small standard gear types TV were used to estimate catch per hour in units of the large TV. The mean CPUE values of 1 cm length intervals were pooled into different length ranges which can partly be assigned to age groups and spawner types (Oeberst 2001). The calculation of mean CPUE values was carried out according the methods given in the BITS manual (website of ICES, ICES 2010). The areas of depth layers and ICES subdivisions used in the calculation procedure were also taken from the BITS manual. For the quarter 4 surveys following length ranges were used

Notation	Length group	Spawning period	Assumed age group
Sum_0	5 cm to 11 cm	Summer	0
Spr_0	12 cm to 19 cm	Spring	0
Sum_1	21 cm to 26 cm	Summer	1
Spr_1	27 cm to 33 cm	Spring	1
Sum_2	34 cm to 41 cm	Summer	2
Spr_2	42 cm to 47 cm	Spring	2
Age_0	5 cm to 19 cm		0
Age_1	21 cm to 33 cm		1
Age_2	34 cm to 47 cm		2

The length ranges, which were used for the quarter 1 surveys (spring), slightly differed due to the growth between November and February/March:

Notation	Length group	Spawning period	Assumed age group
Sum_1	6 cm to 13 cm	Summer	1
Spr_1	14 cm to 21 cm	Spring	1
Sum_2	24 cm to 30 cm	Summer	2
Spr_2	31 cm to 35 cm	Spring	2
Sum_3	37 cm to 42 cm	Summer	3
Spr_3	43 cm to 48 cm	Spring	3
Age_1	6 cm to 21 cm		1
Age_2	24 cm to 35 cm		2
Age_3	37 cm to 48 cm		3

The defined length ranges of the oldest age groups are uncertain due to the increasing overlap of the length range of spring and summer spawners as well as age groups. Furthermore, it must be taken into account that cod larger 35 cm is affected by the fishery due to the minimum landing size of 38 cm and discarding of smaller cod.

The defined length ranges are based on studies of the otolith microstructure (Oeberst and Böttcher, 1998). The different spawning seasons result in bimodal length frequencies of year-class which were detected in the length frequencies of cod during bottom trawl surveys (Fig.3, Oeberst, 2001) where clearly detectable minima were observed between the different length ranges. The poor year-classes 1995 and 2002 with significantly lower CPUE values than the neighboring year-classes (Fig G:4, ICES, 2010) within a range of ~ 10 cm can be clearly detected in the length frequencies of subsequent BITS in November and spring (Fig G:5 and 6). The length range with low frequencies shifted from BITS to BITS between quarter 4 in 1995 and quarter 4 in 1998 (Fig G:5) as well as between quarter 1 on 2002 and quarter 1 in 2004 (Fig G:6). These length ranges can be used as separator of the stronger neighbouring year-classes. The low densities of both the year-class occurred in ICES subdivisions 22, 24 and 25. The figures also illustrate the increasing length range of the strong year-classes 1994 and 1996 as well as 2001 and 2003 and did not show signals that the length ranges of year-class fast expand. Bimodal length distribution of small cod of the same year class in SD22, SD 24 and SD 25 are visible (Q4 2003). Modal value of smallest cod in SD 25 was 9 cm and ~16 cm in SD 24. The figures further suggest that growth of cod is relative stable within the first age groups between 1994 and 2004.

Mean catch in number in units of large TV were estimated for the total area ($CPUE_t$) which summarize cod of both Baltic stocks to describe the development of the CPUE of length ranges. The stratified mean of the total area was used to avoid possible effects of the variable mixing of both cod stocks in the different parts of the total area.

In addition, proportions of cod of defined length ranges within SD 22 and SD 24 were calculated in relation to the total area by means of

$$\frac{\sum_{i=22,24} A_i CPUE_i}{\sum_{i=22,24..28} A_i CPUE_i} * 100$$

where A_i presents the area of ICES subdivisions and mean $CPUE_i$ the mean catch in number per hour of ICES subdivision i. CPUEi can be substituted by Spr_a or Sum_a where a described the chosen age group.

Furthermore, indices of defined stocks ($I_{22\&24}$ – western stock, $I_{25\text{-}28}$, eastern stock) and by spawner types (I_{Spr} and I_{Sum}) were calculated as give below.

$$I_{22\&24}(a) = \sum_{i=22,24} A_i (Spr\_a_i + Sum\_a_i)$$

$$I_{25-28}(a) = \sum_{i=22..28} A_i (Spr\_a_i + Sum\_a_i)$$

$$I_{Spr}(a) = \sum_{i=22,24..28} A_i (Spr\_a_i)$$

$$I_{Sum}(a) = \sum_{i=22,24..28} A_i (Sum\_a_i)$$

The horizontal distribution patterns of the defined length groups of cod were described using Ocean data View (www.awi-bremerhaven.de) where Iso-surface plots with color shading and contouring of gridded fields were calculated based on VG gridding with a scales of 80 in both directions. This method analyzes the distribution of the data points and constructs a variable resolution, rectangular grid, where grid-spacing along X and Y directions vary according to data density. High resolution (small grid-spacing) is provided in regions with good data coverage, whereas in areas of sparse sampling the grid is coarse and resolution is limited.

Results

Mean catch in number per hour in units of large estimated for the total area of BITS ($CPUE_t$) was used to study the representativeness of data of the different length ranges.

$CPUE_t$ values of cod smaller than 20 cm are probably underestimated. Higher $CPUE_t$ values of cod smaller than 20 cm (> 10 ind. hour^{-1}) were only observed during BITS of quarter 1 in 2002, of quarter 4 in 2003 and of quarter 1 in 2004 (Fig G:7) and were low during all other BITS followed by higher $CPUE_t$ values of larger cod during subsequent BITS (exemplary, Fig G:8). Large proportions of smaller cod were observed in SD 22 and 24 during these BITS (compare Fig G:14). The low catches of small cod can't be explained by the mesh size of cod end because the selectivity is very low for cod larger than 11 cm. One possible reason can be that smallest cod are mainly located in the shallow waters of the ICES SD's. These areas can't be intensively covered by the large research vessels "Argos, "Atlantida / Atlantniro", "Baltica" and "Dana". Fishing is also not possible in large areas of shallow waters due rocky bottom.

Figure G:8 also illustrates that catch of cod between 20 cm and 30 cm might also be underestimated, but with less extend. $CPUE_t$ values of cod between 20 cm and 27 cm were estimated less than 20 ind. hour^{-1} during quarter 4 in 2007 and larger than 25 ind. hour^{-1} during the subsequent BITS. In other cases $CPUE_t$ did not decrease from BITS to BITS also increasing cod were affected by natural mortality and fishery from quarter 1 to quarter 4 in 2005 (Fig G:9).

The conclusions based on $CPUE_t$ are supported by the development year-classes of the defined indices $I_{22\&24}$, $I_{25\text{-}28}$, I_{Spr} and I_{Sum} (mean catch per hour * survey area) based on subsequent BITS. Indices of year-classes estimated for both spawner types together in the total Baltic Sea are given in Figure G:10. Low indices of year-classes 2002 and 2004 to 2006 were estimated for age group 0 during BITS in quarter 4 (Age_0(Q4)) and for age group 1 during BITS in quarter 1 (Age_1(Q1)) followed by increasing indices. The developments suggest an underestimation of the year-classes during the first two observations.

Temporal development of spring spawned cod (I_{Spr}) fluctuated with minimum estimates during Age_1(Q1) followed by the maximum values and subsequent decrease (Fig G:11). In contrast to this temporal development of the year-classes 2002 to 2006 of summer spawned cod (I_{Sum}) were different (Fig G:12). Low indices were estimated during Age_0(Q4) and Age_1(Q1) followed by increase and highest values between Age_1(Q4) and Age_2(Q4) and a decrease as Age_3(Q1).

Developments of year-class indices based on areas of current used stock model are given in Figure G:13 and 14. Indices of SD 22 and 24 ($I_{22\&24}$) of year-classes 2003 to 2006 were low and relative stable during all BITS with maximum values between Age_1(Q4) and Age_2(Q1) followed by decreasing indices. Temporal developments of I_{25_28} were comparable with estimates of I_{Sum} suggesting that estimates of eastern Baltic cod stock are correlated with estimates of cod which were spawned in summer.

The proportion of cod within SD 22 and SD 24 (western Baltic cod stock area) in relation to the total stock by defined age groups and length ranges also showed that large proportions of cod which were spawned in spring in SD 22 and SD 24 is concentrated in areas east of Bornholm (Table G3 for quarter 1 and Table G4 for quarter 4). More than 50 % of individuals of Spr_0 in quarter 4 and Spr_1 in quarter 1 stood east of Bornholm. Only in in two years the proportions were larger than 50 % in each of both quarters. In some cases the proportions were less than 25 %. With increasing age the proportions of spring spawned cod in SD 22 and SD 24 decrease and were lower than 25 % for cod smaller than 34 cm. Less than 25 % of summer spawned cod larger than 15 cm were observed in SD 22 and SD 24 with exceptions in quarter 4 2004 and quarter 1 2005. Decreasing proportions of age groups which combine spring spawned and summer spawned cod of the same age group with increasing age also indicate eastward migration of the year-class. This effect is also influenced by the earlier use of the spring spawned cod by the commercial fishery due to larger length.

Proportions of spring spawned cod within the total area in relation to the total stock by age group and year are given in Table G5 and 6 for quarter 1 and 4 BITS, respectively. Same data are presented by year-class and BITS in Table G7. Proportions above 74 % were estimated for Age_0(Q4) and above 49 % for Age_1(Q1). These estimates present overestimations due to lower catchability of young summer spawned cod of used trawl. This effect can be neglected for Age_1(Q4) and later BITS. Proportions varied between 26.5 % and 72.9 % within the estimates of Age_1(Q4) and Age_2(Q1) and were lower during the subsequent BITS. This development can partly explained by the stronger effects of the commercial fishery related to the spring spawned herring due to larger length. However, the proportions of spring spawned cod between 24.6 % and 36 % for Age_3(Q1) suggest that large parts of spring spawned cod stay in ICES SD 25 – 28 because less than 20 % of spring spawned cod were observed in SD 22 and SD 24 (see Tab. 3 and 4). The reduction of the length ranges by neglecting the smallest and largest length interval of all defined length ranges did not significantly change the proportion of spring spawned cod within the total area (Tab. 8 and 9).

Spatial patterns of cod with defined length ranges

Patterns of spatial distribution of cod with defined length ranges are presented in Figures 15 by BITS of quarter 1 and 4 from 2002 to 2010. Each figure of BITS presents 9 maps. Left lowest map shows the realized stations. All other maps show distribution patterns catch in number per hour in units of large TV for defined length ranges. In all cases maximum of 1000 ind. $hour^{-1}$ were used to for shading and contouring the CPUE values. The left two upper maps present the distribution pattern of the length ranges Age_0 and Spr_0 for quarter 4 surveys. The middle maps show the distribution patterns of the length ranges Age_1, Spr_1 and Sum_1 from top to bottom and the right maps presents the distribution patterns of age group 2 with the same sequence for quarter 4. Figures which present the data of quarter 1 have similar structure. However, in this case the data of age groups 1 to 3 were given from left to right.

Age_0, Q4

Distribution patterns of Age_0 were determined by Spr_0 because Sum_0 was not representatively captured. Low densities of year-class 2002 were observed in the total area during quarter 4 in 2002 and quarter 1 in 2003. Higher densities of his year-class were observed during BITS in quarter 4 in 2004. Spr_0 was concentrated west of Bornholm only in 2003 and 2008. During the other years Spr_0 was observed around Bornholm with extensions to the Gdansk Bay (2004).

Age_1, Q1

Distribution pattern of Ag1_1 was also determined by Spr_1 although it can be expected that largest part of Sum_1 are not strongly influenced by the selection characteristics of used trawls. Spatial distribution of Spr_1 is highly variable around Bornholm. Higher densities were also found west of Bornholm (2005) and east of Bornholm (2008). Comparisons of the distribution patterns of the same year-class from Age_0 in quarter 4 to Age_1 in quarter 1 suggest an eastward migration of these cod with different intensity (compare Age_0(Q4) in 2003, Age_1(Q1) in 2004 and Age_1(Q4) in 2004).

Age 1, Q4

Spatial distribution of Age_1 is highly variable with higher densities around Bornholm. However, higher densities were also found east of Bornholm until the eastern coast of SD 28 (2004, 2007, 2008 and 2009). The spatial distribution of Spr_1 suggests that larger proportions of these cods were captured east of Bornholm (2002, 2004, 2005, 2007, 2008 and 2009). On the other hand Sum_1 occurred also in SD 24 with high densities. Only low densities of Sum_1 were observed in SD 22 in the most years.

One conclusion of the high variability of the spatial distribution of juvenile cod is that fixed area can't be proposed to protect juvenile cod. Temporary closures are also difficult to handle due to the high variability of the areas with highest concentrations within short periods.

Cod larger 25 cm is mainly concentrated in SD 24, SD 25 and SD 26 in quarter 1 and 4. Low densities were observed in SD 22. Density of these cods was low northern of 57°N during the most BITS. Cod which were probably spawned in the western Baltic Sea (SD 22 and SD 24) in spring were captured east of Bornholm with high densities in large areas. On the other hand cod which were probably spawned in summer were also observed in SD 24 with variable CPUE values and in SD 22 with lower densities. The overview of the spatial distribution of cod larger 25 cm suggest, that all individuals were concentrated in the same area with low variations between the different length ranges, but, with high variations from BITS to BITS.

Distribution of maturity stages during BITS in quarter 1 and 4

The numbers of cod by BITS, ICES subdivision, sex and maturity stage are given in Figure G:16.

Maturity stages 1 (virgin) and 5 (resting) were combined together. In many cased the number by 1 cm length class is relative low if two sexes and five maturity stages are taken into account. Higher numbers of analyses cod were observed in SD 25 and SD 26 because three vessels sampled biological data.

Quarter 1 SD 22:

Proportions of male with maturity stage between 2 and 4 were higher compared to female and male cod starts maturation with smaller length (smaller minimum size of maturation, Bleil and Oeberst, 1997, 2002). The distributions of maturity stages by sex partly strongly differed (see 2006, 2009 and 2010). Furthermore, the proportion of cod with maturity stage 1 or 5 strongly varied from year to year. (high proportions of cod with maturity stage 1 or 5: female 2003, female 2005, female 2010, high proportion of MS = 3; female 2007 and female 2008)

Quarter 1 SD 24:

Low numbers of spawning cod with maturity stages 3 and 4 were observed with one exception (male 2006). The proportion of maturity stage 2 related to maturity stage 1 or 5 is length dependent and varied from year to year. Cod with maturity stage 1 or 5 were observed in the total length range in all years. It must be taken into account that the BITS in SD 24 mostly started middle of February, the same period were most of the analysed cod in SD 22 were captured.

Quarter 1 SD 25:

Sample size was significantly higher in SD 25 related to SD 22 and SD 24 due to the high number of stations and the realization of all stations by at least three vessels where the standard sample sizes were realized. Stable length range (< 25 cm) was observed with low proportion of maturing cod in most years. Only in 2005, 2006 and 2008 higher proportions of male maturing cod were observed. Proportions of cod with maturity stage 1 or 5 decreased with increasing length and were always low for cod larger than 45 cm, but, varied from year to year (see 2008 male cod and 2010 female cod). Low numbers of spawning cod were observed in some years.

Quarter 1 SD 26

The proportions of cod with maturity stage 1 or 5 were similar to SD 25 taking into account that lower numbers of smallest and largest cod were sampled due to missing catches.

Quarter 1 SD 28

In some years single spawning individuals were observed (2009, 2010, ..), but, the proportions of cod with maturity stage 1 or 5 were similar to SD 26 in most years.

Quarter 1 SD 23 and 27

Determinations of maturity were not carried out in SD 23 and only low sample sizes were realized in SD 27 with a maximum of 10 cod per 1 cm length interval.

Quarter 4 SD 22

Maturity stages 1 and 5 dominate the distribution of maturity stages. Only low numbers of large cod were observed with maturity stage 2 which is in agreement with Bleil and Oeberst (1997).

Quarter 4 SD 24

Maturation status is dominated by stages 1 and 5 and only low proportions of cod with maturity stage 2 were observed. However, in some years large cod were captured with maturity stage 3 or 4 (late summer spawners).

Quarter 4 SD 25

Maturity stages 1 or 5 were always observed for small cod. With increasing length higher numbers of cod with maturity stage2 were captured. In some years large cod were found with maturity stage 3 (spawning) with different numbers by sex (see 2002 and 2003: both sexes, 2004 and 2005 more males than females, 2010: more females than males).

Quarter 4 SD 26

Number of cod with maturity stage 3 and 4 varied from year to year. In 2005 and 2007 large length range were observed with spawning cod. The high proportion of cod with maturity stage 2 can't be assigned to late summer spawners or early spring spawners due to missing more detailed separation of the maturity development.

Quarter 4 SD 28

Spawning cod were captured in many years which higher numbers. However, proportions of cod with maturity stage 2 were low in most years with higher proportions since 2006, especially for cod smaller than 35 cm.

The observations of spawning cod in November suggest that these cod did not start the maturation before July with high probability. Therefore, that these individuals are not added to the proportion of maturing cod based on BITS in spring resulting in an underestimation of the maturity ogive. Successful development of the eggs spawned in November east of Bornholm can explain the higher densities of small cod in the eastern part of SD 28 during BITS in quarter 4 which are assigned to spring spawners based on the defined length classes (see 2004 and 2009).

Clear defined length ranges which can be separated by the proportion of spawning or prespawning cod were not detected which support the defined length ranges of age group and spawner type. Possible reasons are the early sample period in SD 22 and 24 in quarter 1, the low sample sizes, by sex and maturity stages, the combination of cod in one maturity stage which started the maturation and which are immediately before spawning in combination with the overlap of the spawning season of spring spawners and the prespawning season of summer spawners.

Conclusions:

Although the defined length ranges of age group and spawner type influence the results and especially the presented quantitative estimates following conclusions are possible.

Consequences for stock assessment

CPUE values of cod smaller than 20 cm are underestimated.

Permanent or temporary closed fixed area to protect juvenile cod seems to be not useful because the spatial distribution of juvenile cod is highly variable and can change from BITS to BITS.

Cod larger than 25 cm (mixture of spring and summer spawned cod) stays in same areas within SD 24 to SD 28 with highest concentration east of Bornholm. Spatial distribution of theses cods can strongly vary from BITS to BITS.

Uncertainty of stock parameters due to variable mixing in the total Baltic Sea, like

- Year-class indices based on the BITS: Spring spawned cod captured in SD 25 – 28 is assigned to the eastern Baltic stock and vice versa with variable intensity which results in uncertainty of the year-class indices used for tuning.
- High variability of mean weight and mean length at age due to different mean length and mean weight of both spawner types.
- Variability and uncertainty of maturity ogive due to different periods of maturation with consequences for the SSB and the relation between SSB and recruitment.
- Total catch of both cod stocks by the fishery which is used for the stock assessment.

Possible long term strategy

The reproduction success of spring and summer spawning cod is dependent on different parameters. Hydrographical conditions in SD 22 and 24 did not negatively influence the reproduction success until now. The reproduction success is influence determined by the spawner stock, the proportion of spawning females, predation etc. In contrast to this, the reproduction success of summer spawning cod in SD 25 – 28 is significantly influenced by the hydrographical conditions. Therefore, the reproduction success of both cod stock can significantly differ which can’t be describe now without large uncertainties.

Methods which can be used to evaluate or correct the assignment of individuals to spring or summer spawned cod with high accuracy independent of the place and time of capture are required to improve the understanding of the stock dynamic of cod in the Baltic Sea.

Length based assignment of individuals to age group and spawner type which is approved by other independent methods can be one easy to handle option to incorporate the variable mixture of both spawner components and to avoid uncertainty of ageing.

Discussion

Results of BITS suggest a mixing of spring spawned cod (SD 22 & SD 24) and summer spawned cod (SD 24 – 28) within SD 24 to SD28 with variable distribution patterns and increasing concentration of both spawner types in SD 25 and SD 26 with increasing length. The results are based on the assignment of individuals to age group and spawner type based on disjunctive length ranges. Variable growth of cod of the same age from year-class to year-class can result in variable deviations between the estimated stock index and the stock strength. However, the probability seems to be low least of the youngest cod during the first observations. The length ranges of the poor year-classes 1995 and 2002 suggest that growth of young cod is relative stable over long period. Therefore, strong variations of the overlap of the length frequencies of subsequent year-classes are unlikely.

Oeberst (2001) estimated stable mean length for juveniles of both spawner types with small overlap of the length frequencies. The estimated length ranges correspond with estimates based on the micro structure of otoliths (Oeberst and Böttcher, 1998). The overlap of the length frequencies results in an addition of small parts of spring spawned cod (Spr) to summer spawned cod (Sum) and vice versa. This effect can be important if the stock size of one of the spanwer type is more times higher than the other component resulting in a one directional shift from the large stock to the smaller one. This effect might be increase with increasing size (age) of cod and increasing overlap of the length distributions of both spawner types. Stable mean day growth of juvenile cod were estimates between 0.063 to 0.070 mm day^{-1} by Oeberst and Böttcher (1998) and Fey and Linkowski (2006) suggesting a small effect of increasing overlap of the length ranges of spring and summer spawned cod. Rehberg (2010) estimated mean growth between 0.039 and 0.048 mm day^{-1} based on daily increments, but, the resulting mean hatching length of ~ 9 cm based in the regression model seems to be unrealistic. Increasing overlap of the length distributions can result in a higher variability of the estimated stock indices from BITS to BITS, but, it seems to be unlikely that the observed relations between the year-class indices are significantly determined by these effects. Estimates of the relations between the spawner types did not significantly change if defined length ranges are reduced by neglecting of the smallest and largest interval to reduce the possible effects of variable growth it is possible to repeat the studies based on smaller length ranges.

The mixing of both spawner types within large part of the total BITS area is evident independent of the reasons of uncertainty mentioned above. The length ranges of small cod are mainly determined by the spawning season and have stable growth (Oeberst & Böttcher, 1998). Therefore, the uncertainty of the assignment of length to age and spawner type of juvenile cod is minimal. Cod of Spr_0 and Spr_1 were captured in in areas east of Bornholm during all surveys with variable CPUE and spatial distributions. The occurrence of spring spawned cod in SD 25 was shown based on the analyses of otolith micro structures in different years (Oeberst & Böttcher, 1998). This occurrence can be partly explained by wind driven transport of pelagic juveniles from west to east (Hinrichsen et al., 2001).

Cod larger than 25 cm which summaries both spawner types and different age groups is mainly concentrated in the same area with variable spatial distribution patterns from BITS to BITS (see also Oeberst, 2008). Migration of cod between the current used areas of western and eastern Baltic cod stock was studied by different methods. Tagging experiments in the sixties and seventies were used to describe the migration pattern of cod between the feeding and spawning areas (Aro, 1989, 2000, Bagge et al. 1994). Migration of juvenile cod was not described because smallest tagged cod were ~ 30 cm. Neuenfeldt et al (2007) used storage tags to study the migration structure of cod released in the Bornholm Sea and documented extended migration in eastern and western directions (ICES SD 26 and SD 24). They assumed a travelling speed of cod of 20 km day^{-1} and pointed out that faster velocity until 40 km day^{-1} did not result in an increase of uncertainty of the geolocated position. That means that cod need about 10 days from the Bornholm Basin until the Kieler Bight assuming a travelling speed of 20 km day^{-1}.

Studies of meristic and morphometric parameters also showed the occurrences of both Baltic cod stocks within the commercial catches east and west of Bornholm (Müller, 2002). Different distribution pattern of the meristic and morphometric parameters of the defined length ranges of juvenile cod were also found by Lüttkemöller (2010, Diplom thesis).

Independent of the uncertainty of the quantification the study showed that mixing of both spawner types is evident in both areas of the current used stock model. The variability of the mixing both spawner types of different year-classes from BITS to BITS influence different parameters of the stock assessment. The stable growth of juvenile cod results in a low variability of the mean weight at age. The observed variability of the mean weight at age (ICES 2010) can be explained by the variability of the proportions of spring and summer spawned cod in the different areas in combination with the uncertainty of ageing. Further parameters of the stock assessment are also influenced, especially, if spring spawned cod migrates back to SD 22 and SD 24 for spawning like it was proved for cod in Kattegat and Skagerrak by of Svedäng et al. (2007), indicating natal homing.

References

Allendorf, F.W., Ryman, N., Utter, F.M., 1987. Genetics and fishery management past, present, and future, in: Ryman, N., Utter, F.M. (Eds.), Population genetics and fishery management. Washington Sea Grant Program, Seattle, pp. 1-19.

Aro, E. 1989. A review of fish migration patterns in the Baltic. Rapport et Procès–Verbaux des Reunions du Conseil International pour l'Exploration de la Mer, 190: 72−96.

Aro, E. 2000. The spatial and temporal distribution patterns of cod (*Gadus morhua callarias* L.) in the Baltic Sea and their dependence on environmental variability-implications for fishery management. Academic Dissertation, 76 pp.

Bagge, O. and Steffensen, E. 1980. Growth patterns in otoliths as indicator for mixing of stocks. ICES CM 1980/ J:12.

Bagge, O., Thurow, F., Steffensen, E., and Bay, J. 1994. The Baltic cod. Dana, 10: 1–28.

Begg, G. A. and Waldman, J. R. 1999. An holistic approach to fish stock identification. Fisheries Research 43: 35−44.

Berner, M. 1968. Einige orientierende Untersuchungen an den Otolithen des Dorsches (*Gadus morhua* L.) aus verschiedenen Regionen der Ostsee. Fischereiforschung Rostock 6 (1): 77–86.

Berner, M., Müller, H., 1989. Discrimination between „Baltic cod“(*Gadus morhua callarias* L.) and "Belt Sea cod" (*Gadus morhua morhua* L.) by means of morphometric and meristic characters. ICES Counc. Meet. Pap. J. 13, 19 pp.

Berner, M., Müller, H. 1990. Zur Trennung von eigentlichem Ostseeedorsch (*Gadus morhua callarias* L.) und „Beltseedorsch" (*Gadus morhua morhua* L.) mittels Diskriminanzanalyse. Fisch.-Forsch. 28 (3), 46-49.

Bleil, M., Oeberst, R. 1997. The timing of the reproduction of cod (Gadus morhua morhua) in the western Baltic and adjacent areas. ICES C.M. 1997 / CC:02, 33 pp.

Bleil, M. and Oeberst, R. 2002. Spawning areas of the cod stock in the western Baltic Sea and minimum length at maturity. Archive of Fisheries and Marine Research 49: 243–258.

Bleil, M., Oeberst, R. and Urrutia, P. 2009. Seasonal maturity development of Baltic cod in different spawning areas – importance of the Arkona Sea for the summer spawning stock. Journal of Applied Ichthyology 25 (1): 10–17.

Birjukov, N. P. 1969. Spawning communities of Baltic cod and the extent of their mixing. ICES CM 1969/ F: 07.

Börje, M.; Fogelgren, J.-E.; Tengelin, B.; Ulmestrand, M., 1985: Length and maturity of cod (Gadus morhua L.) in the Skagerrak-Kattegat area in February 1981. Fish Board of Sweden. Institute of Marine Research, 308: 11 pp.

Cadrin, S. X., and Friedland, K. D. 1999. The utility of image processing techniques for morphometric analyses and stock identification. Fisheries Research 43: 129–139.

Cadrin, S. X., Friedland, K. D., and Waldman, J. R. 2005. Stock identification methods. Applications in Fishery Science. Elsevier Academic Press, 719 pages.

Carvalho, G. R. and Hauser, L.1994. Molecular genetics and the stock concept in fisheries. Reviews in Fish Biology and Fisheries 4: 326–350.

Campana, S. E., Chouinard, G. A., Hanson, J. M., and Frèchet, A. 1999. Mixing and migration of overwintering Atlantic cod (*Gadus morhua*) stocks near the mouth of the Gulf of St. Lawrence. Canadian Journal of Fisheries and Aquatic Science 56: 1873–1881.

Fey, P.D., Linkowski, T.B. 2006. Predicting juvenile cod (Gadus morhua) age from body and otolith measurements. ICES J. Mar. Sci. 61:1269-1284.

Hammer, C. and Zimmermann, C. 2005. The role of stock identification in formulating fishery management advice. In: Cadrin, S. X., Friedland, K. D., and Waldman, J. R. (Eds.) 2005. Stock identification methods. Applications in Fishery Science. Elsevier Academic Press, p. 631–658.

Hinrichsen, H.-H., Böttcher, U., Oeberst, R., Voss, R., Lehmann, A., 2001. The potential for advective exchange of the early life stages between the western and eastern Baltic cod (*Gadus morhua* L.) stocks. Fish Oceanogr, 10, pp. 249-258.

Hüssy, K. 2010. Why is age determination of Baltic cod (Gadus morhua) so difficult? ICES J. of Mar. Sci. 67: 8pp

ICES 2006. Report of the Study Group on Ageing Issues of Baltic Cod (SGABC). ICES CM 2006/BCC:08, 45 pp.

ICES. 2010a. Report of the Baltic International Fish Survey Working Group (WGBIFS). ICES CM 2010/SSGESST:07, 468pp.

ICES. 2010b. Report of the Baltic Fisheries Assessment Working Group (WBGFAS). ICES CM 2010/ACOM:12, 630pp.

Jamieson, A., Otterlind, G., 1971. The use of cod blood protein polymorphisms in the Belt Sea, the Sound and the Baltic Sea. Rapp. Proc. Verb. 161, 55-63.

Karasiova, E. M., Voss, R., and Eero, M. 2008. Long-term dynamics in eastern Baltic cod spawning time: from small scale reversible changes to a recent drastic shift. ICES CM 2008/J:03

Lüttkemöller, E. 2010. Untersuchungen zur Bestandsidentifizierung juvenile Dorsche der Ostsee auf der Basis meristischer Merkmale. Universität Rostock, Diplom thesis, 92 pp.

MacKenzie, B., Hinrichsen, H. H., Plikshs, M., and Wieland, K. 2000. Quantifying environmental heterogeneity: estimating the size for successful cod egg development in the Baltic Sea and its influence on recruitment. Marine Ecology Progress Series, 193: 143–156.

Müller, H., 2002. The distribution of “Belt Sea cod” and „Baltic cod“ in the Baltic Sea from 1995 to 2001 estimated by discriminant analysis of the number of dorsal fin rays. ICES Counc. Meet. Pap. L 16, 23 pp.

Neuenfeldt, S., Hinrichsen, H—H., Nielsen, A., Andersen, K. 2007. Reconstructing migrations of individual cod (*Gadus morhus* L.) in the Baltic Sea by using electronic data storage tags. Fisheries Oceanography, 16:6, 526-535.

Moth-Poulsen, T. 1982. Genetic variation of cod from the Danish Sound: Interrelations of stocks from adjacent waters. ICES C.M. 1982/G: 46

Nielsen, E. E, Hansen, M.M., Ruzzante, D. E., Meldrup, d. and Grønkjær, P. 2003. Evidence of a hybrid-zone in Atlantic cod (*Gadus morhua*) in the Baltic and the Danish Belt Sea revealed by individual admixture analysis. Molecular Ecology 12: 1497–1508.

Nissling. A. and Westin, L. 1997. Salinity requirements for successful spawning of Baltic and Belt Sea

cod and the potential for cod stock interactions in the Baltic Sea. Marine Ecology Progress Series 152: 261–271.

Oeberst, R. 2001. The importance of the Belt Sea cod for the eastern Baltic cod stock. Arch. Fish. Mar. Res. 49(2), 2001, 83-102.

Oeberst, R. 2000. Proposal for the stratification of the Baltic Sea for the Baltic International Trawl Survey. ICES C.M. 2000 / K:21, 28 pp

Oeberst, R. 2008. Distribution pattern of cod and flounder in the Baltic Sea based on international coordinated trawl surveys. ICES CM 2008/J:09, 28 pp.

Oeberst, R. 1999. Proposal for the stratification of the Baltic Sea for the Baltic International Trawl Survey. Working Paper für das IDSBITS-Projekt Meeting, Lysekil, Schweden 8-12 December 1999

Oeberst, R. 2008. Optimum depth stratification during the BITS in spring and autumn. Working document of Baltic International Fish Survey Working group 31.3. – 4.4.2008. 19 pp.

Oeberst, R. 2010. Estimation of the CPUE in the Russian zone based on the CPUE values of the remaining area in SD 26. Working document of the Working group on Baltic International Fish Survey, in Klaipeda, Lithuania, 22 – 26 March 2010, 21 pp.

Oeberst, R., Böttcher, U., 1998. Development of juvenile Baltic cod described with meristic, morphometric and Sagitta otolith parameters. ICES Counc. Meet. Pap. CC 15, 29 pp.

Reeves, S.A. 2003. A simulation study of the implications of age-reading errors for stock assessment and management advice. ICES Journal of Marine Science, 60: 314–328.

Rehberg, S. 2010. Validation on age determination of juvenile western Baltic cod (Gadus morhua L.). Diplom thesis, 86 pp.

Ruzzante, D. E., Taggart, C. T., and D. Cook. 1996b. Spatial and temporal variation in the genetic composition of a larval cod (Gadus morhua) aggregation: cohort contribution and genetic stability. Can. J. Fish. Aquat. Sci 53: 2695-2705

Svedäng, H., Righton, D., Jonsson, P., 2007. Migratory behavior of Atlantic cod *Gadus morhua*: natal homing is the prime stock-separating mechanism. Mar. Ecol. Prog. Ser., Vol. 345, 1–12.

Sick, K. 1965. Haemoglobin polymorphism of cod in the Baltic and the Danish Belt Sea.

Hereditas 54: 49–73.

Westin, L. and Nissling, A. 1991. Effects of salinity on spermatozoa motility, percentage of fertilized eggs and egg development of Baltic cod *(Gadus morhua),* and implications for cod stock fluctuations in the Baltic. Marine Biology 108: 5–9.

Wieland, K., Jarre-Teichmann, A., and Horbowa, K. 2000. Changes in the timing of spawning of Baltic cod: possible causes and implications for recruitment. ICES Journal of Marine Science 57: 452–464.

Table G1: Overview of the coverage of the survey area by country, vessel, trawl and SD

Country	Vessel	Trawl	22	23	24	25	26	27	28
Denmark	Hafvisken	TVS	x	x					
Germany	Solea	TVS	x		x				
Denmark	Dana	TVL				x	x		
Estonia	Commercial cutter	TVS							x
Latvia	Commercial cutter / Baltica	TVS / TVL					x		x
Lithuania	Darius	TVS					x		
Poland	Baltica	TVL				x	x		
Russia	Atlantida / Atlantniro					x	x		
Sweden	Agos	TVL				x	x	x	x

Table G2: Number of hauls which can be used for estimating stock indices by year and quarter

Year	Quarter 1	Quarter 4
2002	195	91
2003	300	182
2004	250	184
2005	331	242
2006	308	195
2007	304	

Table G3: Proportion of cod captured in SD 22 and SD 24 related to the total area by year and defined length ranges of quarter 1 (Sum_1: summer spawned cod of age group 1, Spr_1: spring spawned cod of age group 1).

Year	Quarter	Sum_1	Spr_1	Sum_2	Spr_2	Sum_3	Spr_3
2002	1	74.3	47.4	15.7	15.8	9.4	8.0
2003	1	12.0	47.0	25.5	18.4	14.1	8.4
2004	1	21.6	54.3	15.5	9.0	16.5	15.9
2005	1	20.9	14.4	30.5	50.0	34.0	20.2
2006	1	50.5	66.3	11.1	20.7	27.5	24.7
2007	1	8.4	20.1	16.8	10.8	16.6	19.7
2008	1	14.2	8.6	11.4	12.6	12.8	11.7
2009	1	9.6	39.6	11.0	9.2	8.1	7.7
2010	1	7.7	16.8	13.3	12.1	8.2	5.1

Table G4: Proportion of cod captured in SD 22 and SD 24 related to the total area by year and defined length ranges of quarter 4 (Sum_0: summer spawned cod of age group 0, Spr_0: spring spawned cod of age group 0).

Year	Quarter	Sum_0	Spr_0	Sum_1	Spr_1	Sum_2	Spr_2
2002	4	32.5	27.7	23.7	11.1	7.5	4.2
2003	4	45.9	74.5	6.8	10.3	10.0	6.7
2004	4	47.5	10.7	33.7	36.3	9.8	5.0
2005	4	65.9	34.2	9.0	15.3	10.0	6.4
2006	4	25.0	16.2	8.0	7.4	11.3	9.0
2007	4	29.6	20.1	9.5	9.5	6.4	5.5
2008	4	53.9	60.6	4.8	3.4	2.9	2.7
2009	4	52.0	16.3	11.5	11.5	7.1	5.0

Table G5: Proportion of spring spawned cod (I_{Spr}) in the total area related to the total stock (I_{Spr} +

T_{Sum}) of quarter 1 by age group and year

Year	Quarter	Age 1	Age 2	Age 3
2002	1	61.0	28.0	39.8
2003	1	49.4	45.4	27.2
2004	1	54.1	28.2	36.5
2005	1	93.2	26.5	30.0
2006	1	72.3	50.5	24.6
2007	1	65.9	38.2	29.4
2008	1	85.3	38.1	27.4
2009	1	63.6	49.3	33.2
2010	1	92.6	49.8	36.0

Table G6: Proportion of spring spawned cod (I_{Spr}) in the total area related to the total stock (I_{Spr} + T_{Sum}) of quarter 4 by age group and year

Year	Quarter	Age 0	Age 1	Age 2
2002	4	91.5	63.7	19.7
2003	4	70.3	35.6	33.4
2004	4	95.8	36.7	27.3
2005	4	81.9	72.3	21.4
2006	4	81.9	54.1	18.4
2007	4	87.5	55.3	23.1
2008	4	74.2	70.9	27.4
2009	4	89.6	54.6	28.1

Table G7: Proportion of spring spawned cod (I_{Spr}) in the total area related to the total stock (I_{Spr} + T_{Sum}) of quarter 1 by age group and year based on reduced length ranges

Year	Quarter	Age 1	Age 2	Age 3
2002	1	59.2	23.9	39.6
2003	1	43.5	40.3	26.3
2004	1	52.0	23.5	36.4
2005	1	92.0	23.1	30.3
2006	1	71.3	47.1	24.6
2007	1	65.0	32.6	29.2
2008	1	81.8	34.3	27.3
2009	1	58.9	45.6	32.5
2010	1	91.1	45.9	35.3

Table G8: Proportion of spring spawned cod (I_{Spr}) in the total area related to the total stock (I_{Spr} + T_{Sum}) of quarter 4 by age group and year based on reduced length ranges

Year	Quarter	Age 0	Age 1	Age 2
2002	4	88.6	62.5	17.1
2003	4	70.9	33.1	30.3
2004	4	96.8	38.0	24.4
2005	4	82.3	75.8	20.0
2006	4	78.7	55.6	15.6
2007	4	86.1	56.6	20.6
2008	4	75.4	73.3	24.8
2009	4	88.2	56.9	25.2

Table G9: Proportion of spring spawned cod (Spr) in the total area by year-class and BITS from Age_0(Q4) to Age_3(Q1).

	Year-class						
BITS	2002	2003	2004	2005	2006	2007	2008
Age_0(Q4)	91.5	70.3	95.8	81.9	81.9	87.5	74.2
Age_1(Q1)	49.4	54.1	93.2	72.3	65.9	85.3	63.6
Age_1(Q4)	35.6	36.7	72.3	54.1	55.3	70.9	54.6
Age_2(Q1)	28.2	26.5	50.5	38.2	38.1	49.3	49.8
Age_2(Q4)	27.3	21.4	18.4	23.1	27.4	28.1	
Age_3(Q1)	30.0	24.6	29.4	27.4	33.2	36.0	

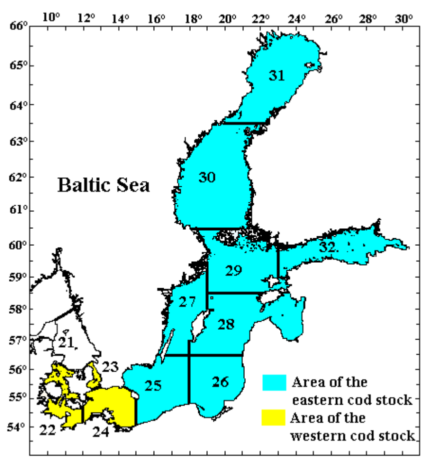


Figure G:1: Baltic Sea with ICES subdivisions (SD) and areas of the two cod stocks as used by ICES assessment working groups. SD 21 =Kattegat, SD 22 = Belt Sea, SD 23 = Øresund, SD 24 = Arkona Sea, SD 25 = Bornholm Sea (**Oeberst, 2001**).

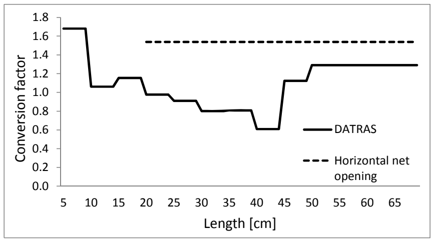


Figure G:2: Conversion factors between large and small TV by 5 cm length intervals CPUE(TVL) = CF * CPUE(TVS)

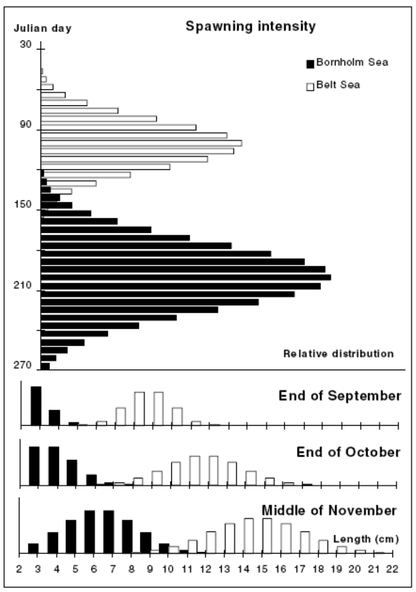


Figure G:3: Illustration of the relationship between the different spawning seasons of the western and eastern Baltic cod stocks and the resulting length distributions of the two components (**Oeberst, 2001**).

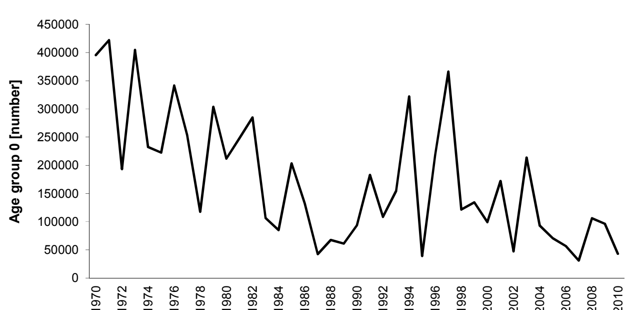


Figure G:4: Development of the age group 0 in numbers of the western Baltic cod stock estimated by WGBFAS (**ICES, 2010**)

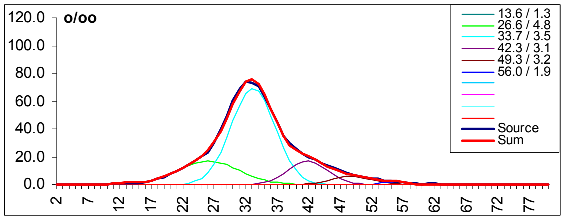
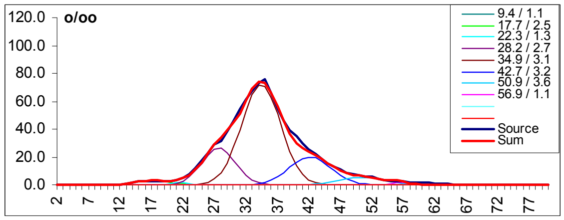
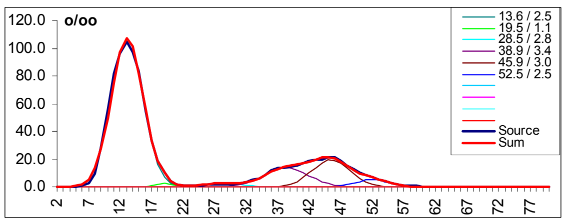
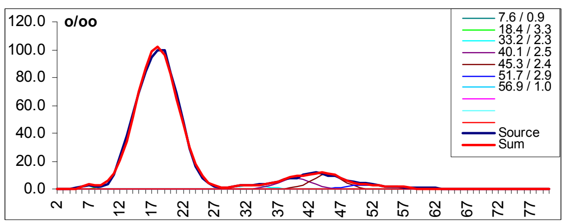
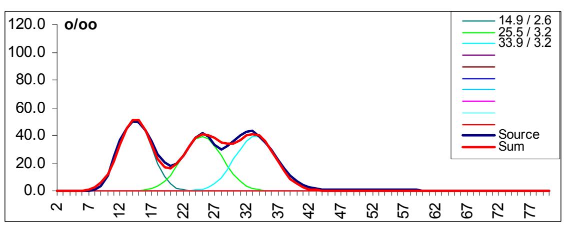
Year	Period	Length frequency of cod in the ICES subdivision 24
1995	Nov.	
1996	Spring	
1996	Nov.	
1997	Spring	
1998	Nov.	

Figure G:5: Length distributions of cod in the Arkona Sea in spring and November between 1995 and 1998. Black line: frequency of the sample, red line: length frequency based on normally distributed components, thin colour lines: length frequencies of normally distributed cohorts (Oeberst, 1999). The figures present the mean and the standard deviation of the normally distributed length cohorts.

Belt Sea (SD 22)	Arkona Sea (SD 24)	Bornholm Sea (SD 25)

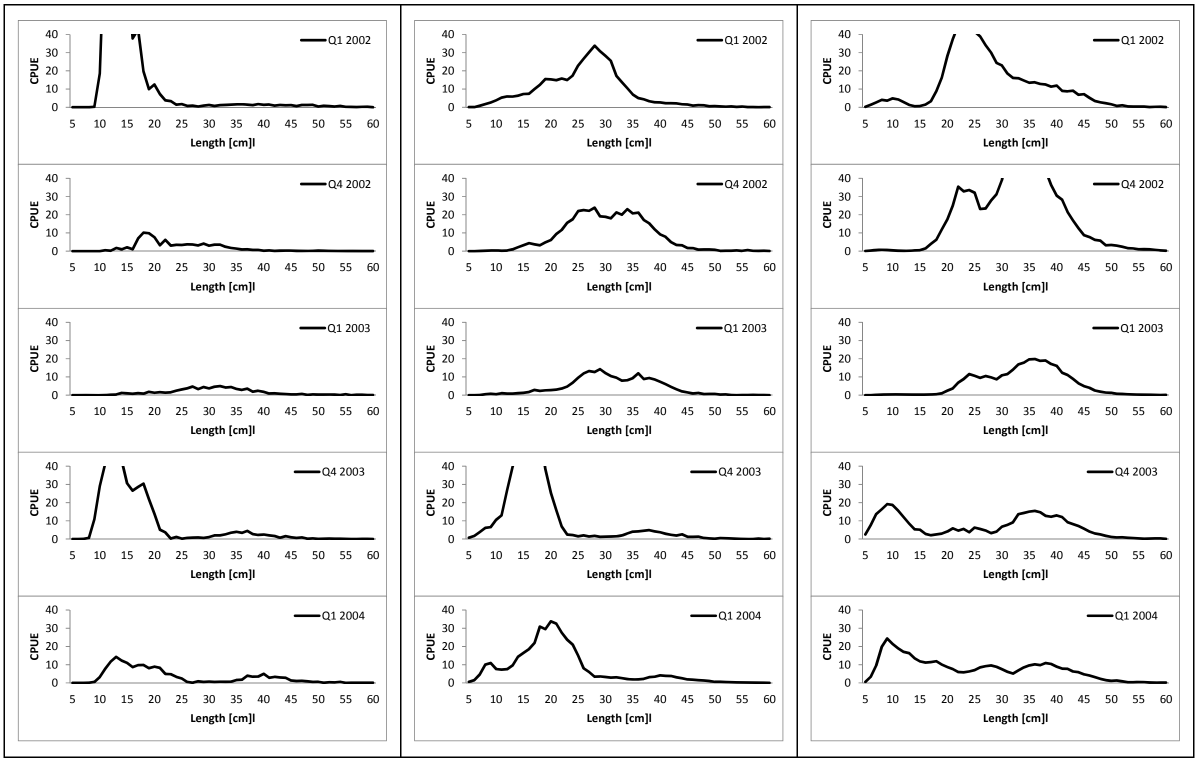


Figure G:6: Length distributions of catch per hour of cod in the Belt Sea, Arkona Sea and Bornholm Sea during subsequent BITS from quarter 1 in 2002 to quarter 1 in 2004.

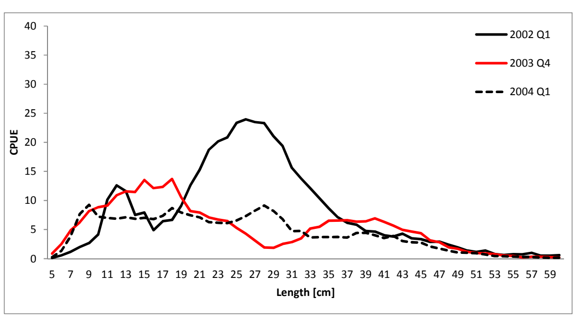


Figure G:7: Mean catch in number per hour in units of the large TV estimated for the total area of BITS during quarter 1 in 2002, during quarter 4 in 2003 and during quarter 1 in 2004.

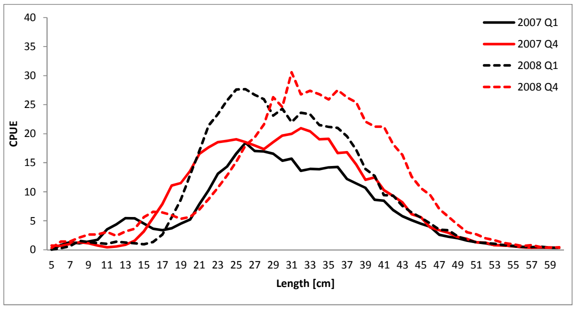


Figure G:8: Mean catch in number per hour in units of the large TV estimated for the total area of BITS between during quarter 1 in 2007 and quarter 4 in 2008.

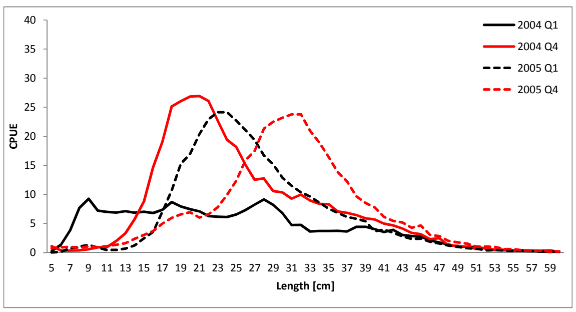


Figure G:9: Mean catch in number per hour in units of the large TV estimated for the total area of BITS between during quarter 1 in 2004 and quarter 4 in 2005.

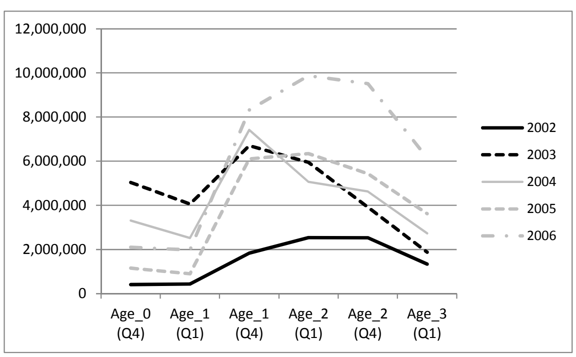


Figure G:10: Development of the total stock indices $I_{22\&24}$+$I_{25\text{-}28}$ from Age_0(Q4) to Age_3(Q1) by year-class

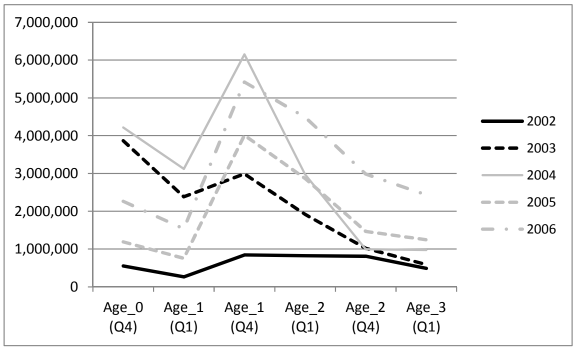


Figure G:11: Development of indices of spring spawned cod (I_{Spr}) from Age_0(Q4) to Age_3(Q1) by year-class

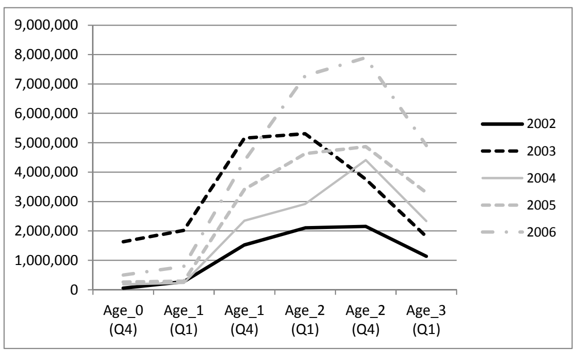


Figure G:12: Development of indices of summer spawned cod (I_{Sum}) from Age_0(Q4) to Age_3(Q1) by year-class

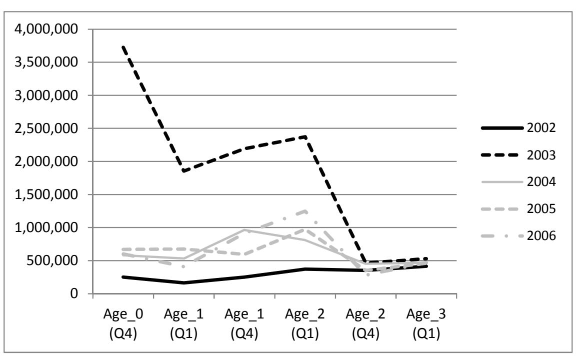


Figure G:13: Development of indices of western cod stock area ($I_{22\&24}$) from Age_0(Q4) to Age_3(Q1) by year-class

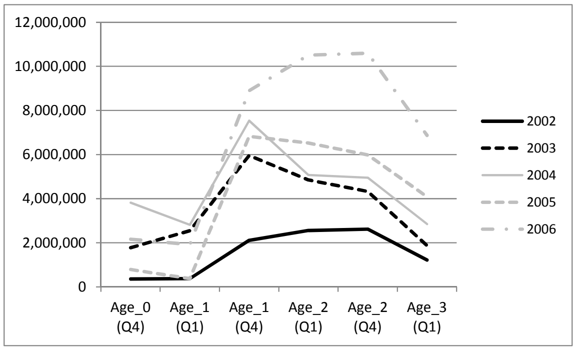


Figure G:14: Development of indices of eastern cod stock area ($I_{25\text{-}28}$) from Age_0(Q4) to Age_3(Q1) by year-class

ANNEX G: PT.2 EVALUATION OF MIGRATION FROM CATCH DATA

Structure of cod stock and catch in the Eastern and Western Baltic

Cod stock structure by length-groups in ICES SDs 22, 24 and 25 was analysed using data from ICES BITS survey in 1st and 4th quarter. This was done by calculating yearly rates of cod CPUE for the period 2001-2009 as the CPUE per length group divided by the CPUE for all length groups. This was done separately for ICES Subdivisions 22, 24 and 25 and for 1st and 4th quarter per year (Figures G10 an G11).

Cod landings structure in SDs 22, 24, and 25 was analysed using Danish cod landings by sorting categories (Figure G12).

Both the stock and landings structure appeared to be similar between SD 24 and 25, but different from SD 22. This pattern is common for all analysed years. Similar stock structure in SD 24 and 25 indicates mixing between the two areas, which has been the case during entire analysed time period.

Recent changes in catch and effort distribution

In recent years, the sub-component in SD 24 in the Western Baltic has become more important as the major part of cod catches in the Western Baltic is currently taken in SD 24 (Figure G13). At the same time, relatively higher stock in the Eastern Baltic (Figure G14) might have increased the proportion of the Eastern Baltic cod in SD 24. This is supported by increased fishing intensity (indicated by VMS data) in the area south of Bornholm (close to the border between Eastern and Western Baltic cod). In 2009, 30% of the Danish fishing effort in SD 24 was allocated to the ICES statistical square 38G4, which corresponds to the area south of Bornholm (Figures G15 and G16). The proportion of cod landings in this square has also been increasing in recent years. The proportion of Danish cod landings in SD 22-24, taken in this statistical square increased from app. 5% in 1995-2004 to 20% in 2009 (Figure G17).

Potentially larger proportion of cod of Eastern origin in the Western Baltic area may have introduced relatively larger bias to the stock assessment for the Western Baltic cod stock for recent years. Consequently, the fishing mortalities obtained from the assessment may not represent fishing mortality on the ‘true’ Western Baltic stock.

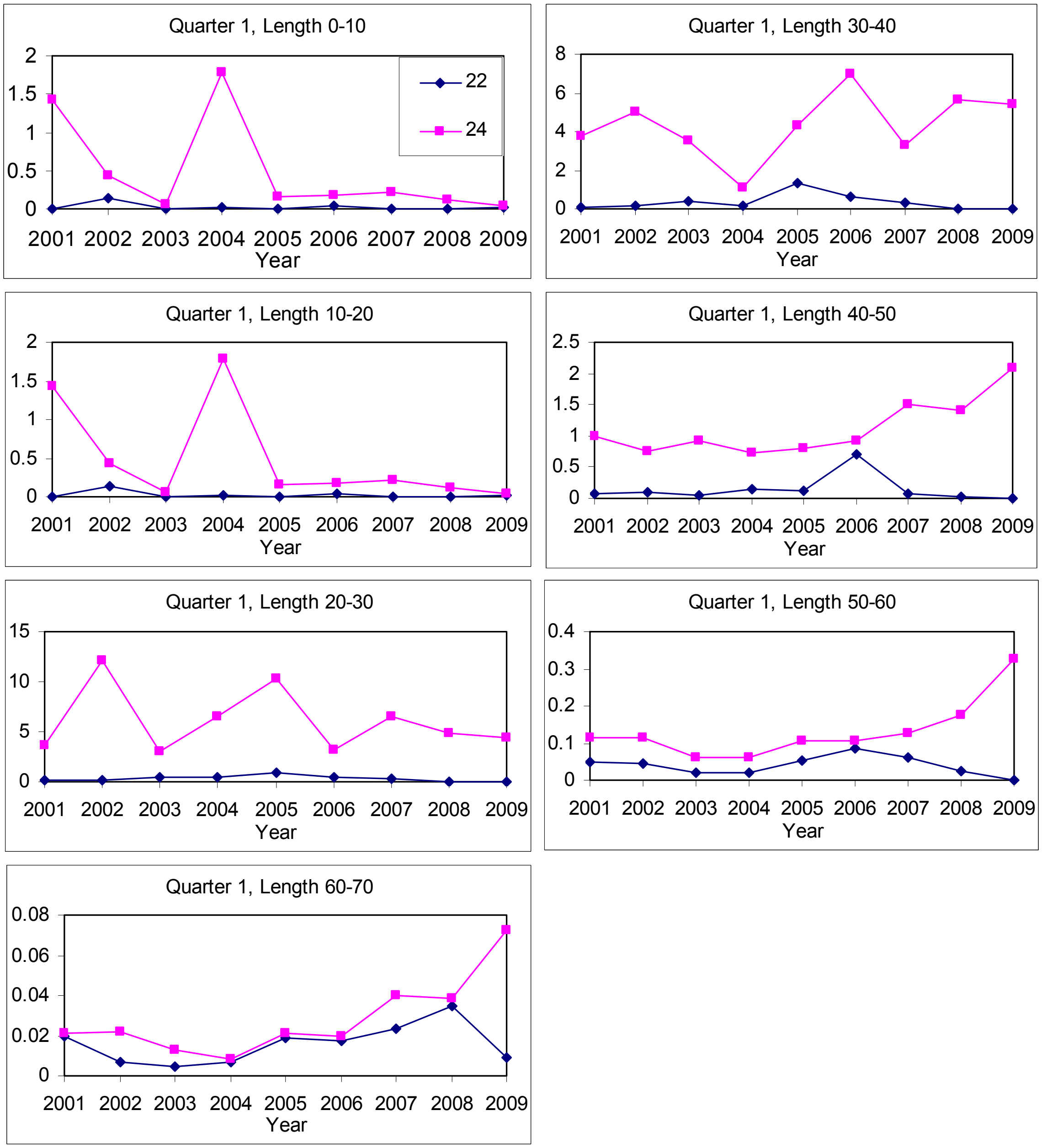


Figure G10a. Fractions of CPUE in the ICES BITS 1st quarter survey by length groups and sub-divisions (SD 22 and SD 24). The fractions (shown on *y* axis) are calculated as the CPUE per length group divided by the CPUE for all length groups.

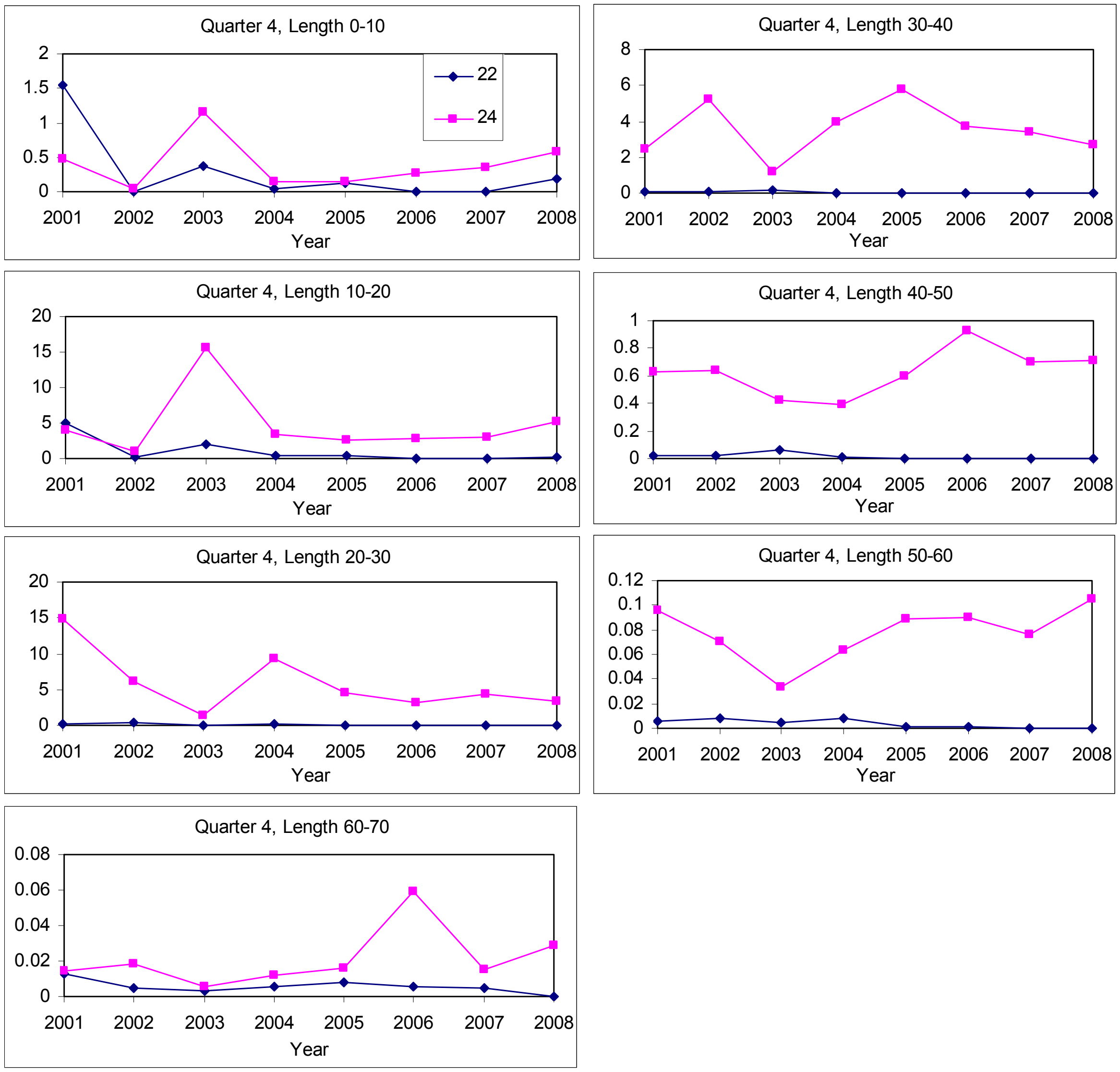


Figure G10b. Fractions of CPUE in the ICES BITS 4th quarter survey by length groups and sub-divisions (SD 22 and SD 24). The fractions (shown on *y* axis) are calculated as the CPUE per length group divided by the CPUE for all length groups.

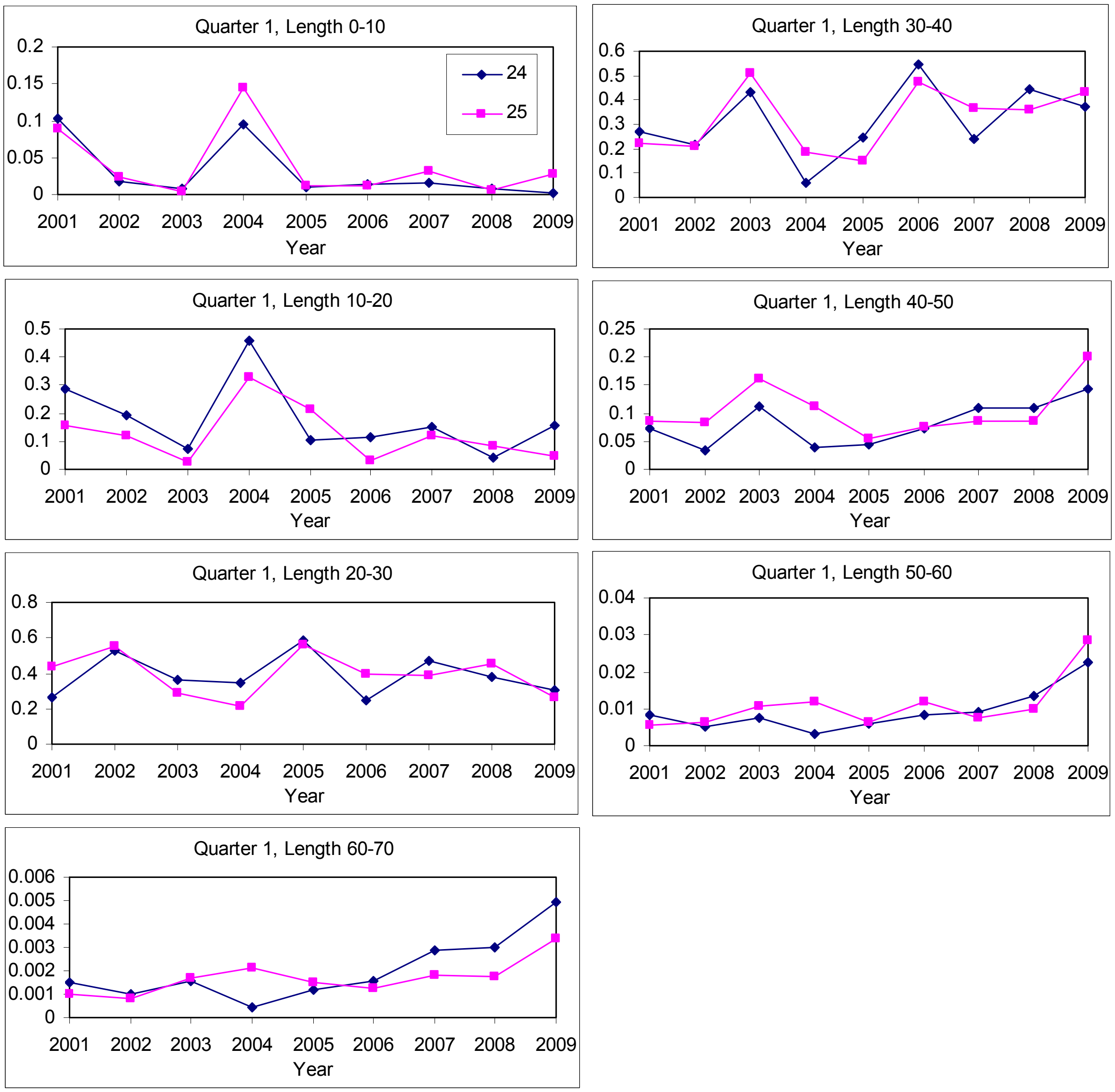


Figure G11a. Fractions of CPUE in the ICES BITS 1st quarter survey by length groups and sub-divisions (SD 24 and SD 25). The fractions (shown on *y* axis) are calculated as the CPUE per length group divided by the CPUE for all length groups.

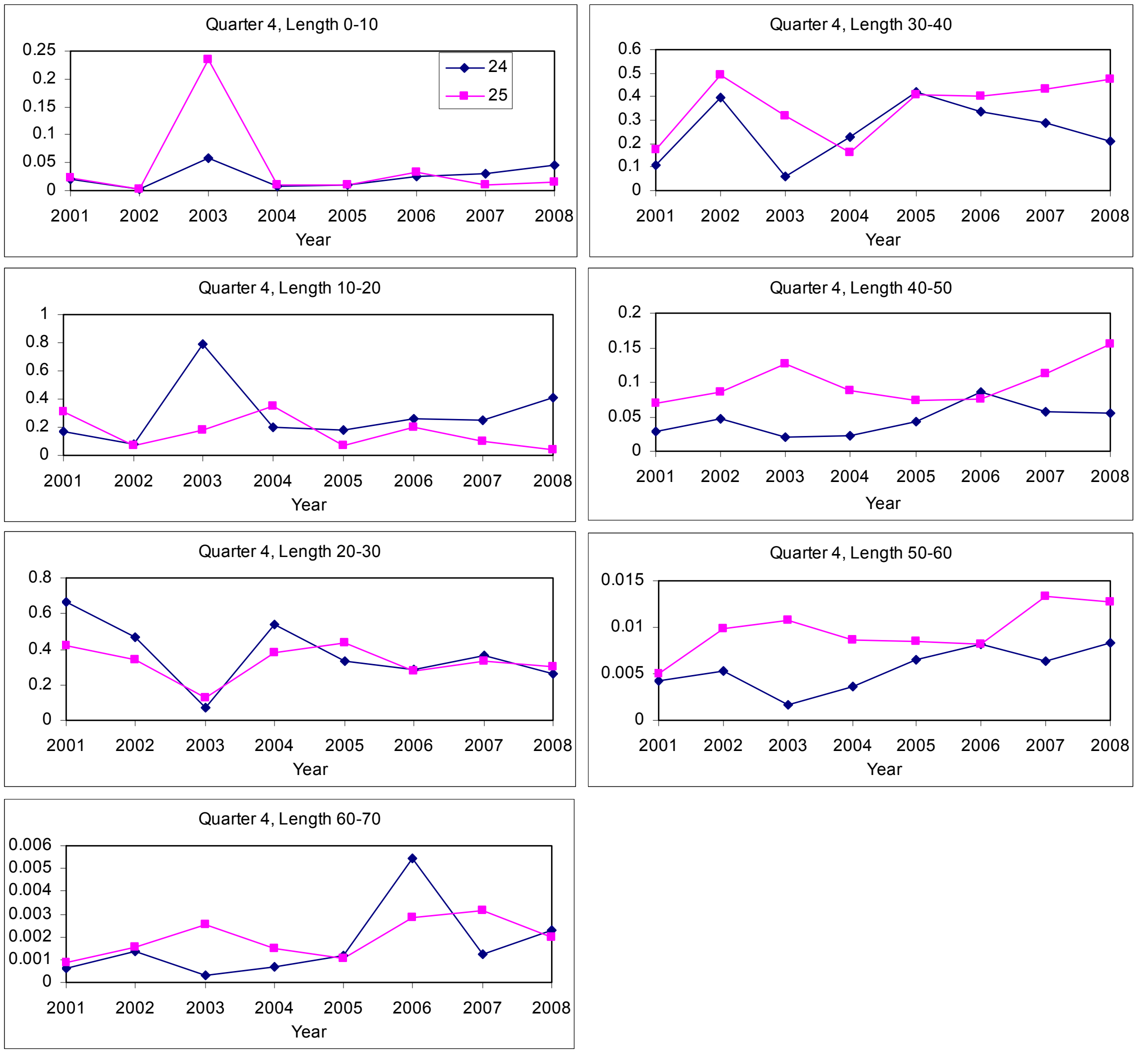


Figure G11b. Fractions of CPUE in the ICES BITS 4th quarter survey by length groups and sub-divisions (SD 24 and SD 25). The fractions (shown on y axis) are calculated as the CPUE per length group divided by the CPUE for all length groups.

Figure G12. Relative distribution of Danish cod landings by sorting categories in SDs 22, 24 and 25. Categories from 1 to 5 represent size groups by weight from largest (1) to smallest (5) fish. (5: 0.3-1kg; 4: 1-2 kg; 3: 2-4 kg; 2: 4-7 kg; 1: >7 kg)

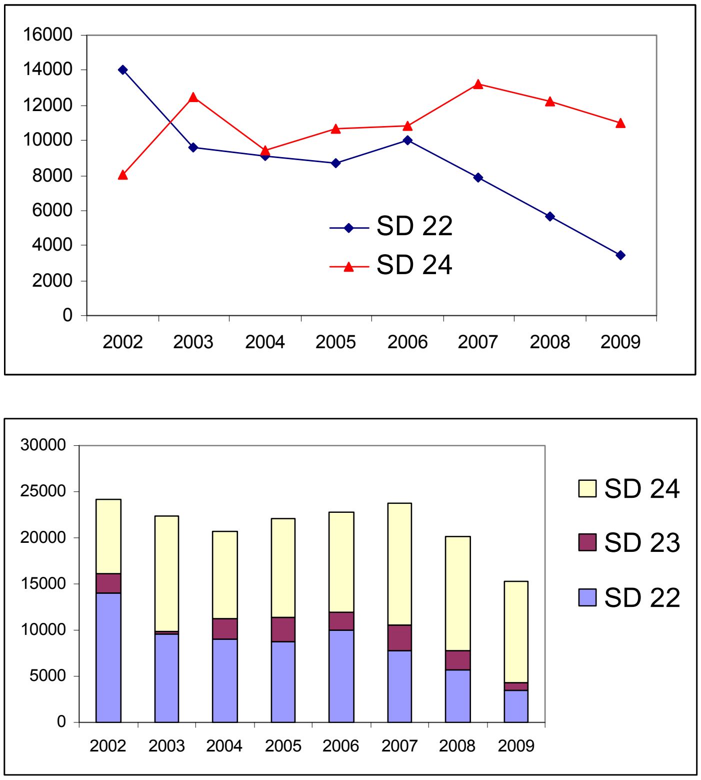


Figure G13. Cod landings in the Western Baltic by SD. The upper panel shows the landings trajectory in 2002-2009 separately for SD 22 and 24; the lower panel shows the dynamics of total landings, including the proportion of each SD in total landings.

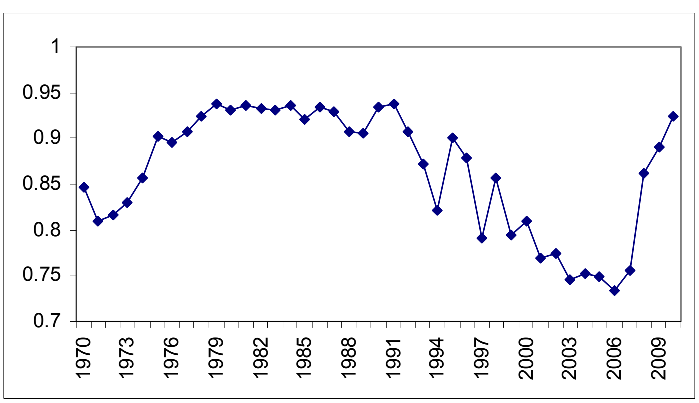


Figure G14. Fraction of the spawner biomass of the Eastern Baltic cod from the total cod SSB in the Eastern (EB) and Western Baltic (WB) areas combined (EB/(EB+WB)).

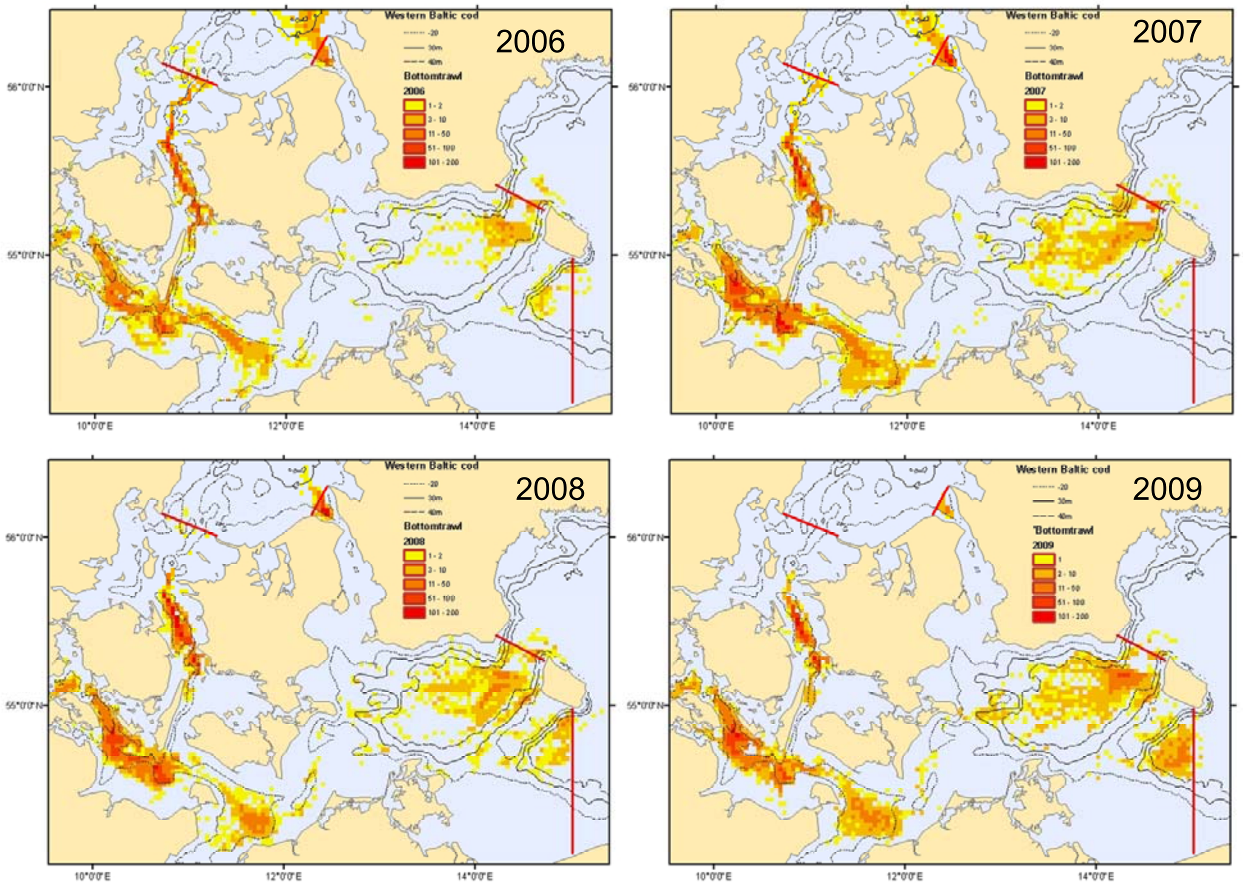


Figure G15. VMS data from the Danish bottom trawlers in 2006-2009 with catching more than 25% cod and fishing with a speed between 2-4 knots, were landings has been reported to be in the Western Baltic Sea.

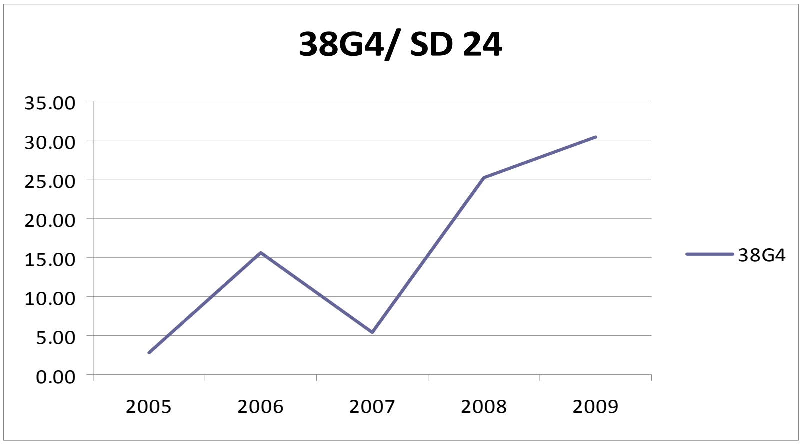


Figure G16. Proportion of Danish VMS data in SD 24 that is recorded in ICES statistical square 38G4 (south of Bornholm).

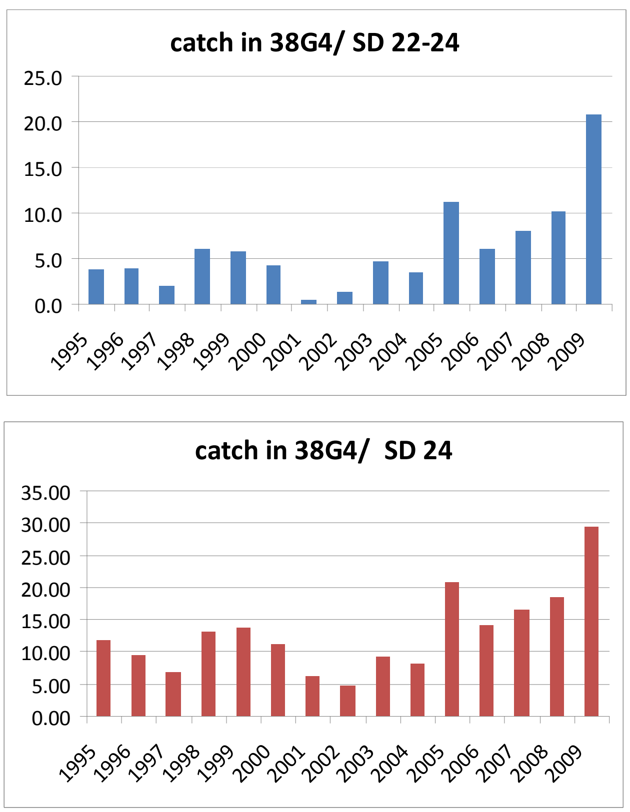


Figure G17. Proportion of Danish cod landings in SD 22-24 combined and in SD 24, which have been taken in ICES statistical square 38G4 (south of Bornholm).

ANNEX G: PT.3 SIMULATION RESULTS ON POTENTIAL MIGRATION EFFECTS BETWEEN THE TWO BALTIC COD STOCKS

A set of MSE simulation runs were made for testing sensitivity and robustness of the management plan to a possible migration effect between the two Baltic cod stocks. These simulations were made with a modified version of the model from Bastardie *et al.* (2010a) where the two stocks were coupled in the operating model. The simulations covered ages 2-7 of both stocks. All other model settings used in the simulations were identical to those used in Bastardie *et al.* (2010a), e.g. start year=2008, same XSA settings, CV_InE=0.3, CV_CaE=0.15, CV_IE=0.0.

Given the migration levels tested and the level of recruitment, the migration effects seem not to influence the ability of the management plan to achieve its F-targets. Based on the 2008 MSE settings there would have been more than 50% probability that F would be below target in the medium term prediction period, and F would be at the same level during 2015 to 2020 when migration was included compared to when there is no migration. In case of migration of 3% of the ages 3-7 of Eastern Baltic cod to the Western Baltic and 10% of ages 1-2 Western Baltic cod to the Eastern Baltic, then the resulting biomass (SSB) of the Western Baltic cod would in the medium term projection period increase to more than 100 000 t given the 2008 MSE settings and used level of recruitments.

Table G.10 Scenarios of different levels of migration between the Eastern and Western Baltic cod stocks by age group tested. For example for the run 6, 3% each year of ages 4 to 7 of Eastern Baltic cod migrate to the Western Baltic, while 10% of age 2 and 3 Western Baltic cod migrate to the Eastern Baltic. Number of iterations is N=50 for each simulation.

Proportion per age		East to West						West to East					
Run	N	2	3	4	5	6	7	2	3	4	5	6	7
1	50	0	0	0	0	0	0	0	0	0	0	0	0
2	50	0.03	0.03	0.03	0.03	0.03	0.03	0	0	0	0	0	0
3	50	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1
4	50	0	0	0	0	0	0	0.1	0.1	0	0	0	0
5	50	0	0	0.03	0.03	0.03	0.03	0	0	0	0	0	0
6	50	0	0	0.03	0.03	0.03	0.03	0.1	0.1	0	0	0	0
7	50	0	0	0.01	0.01	0.01	0.01	0	0	0	0	0	0

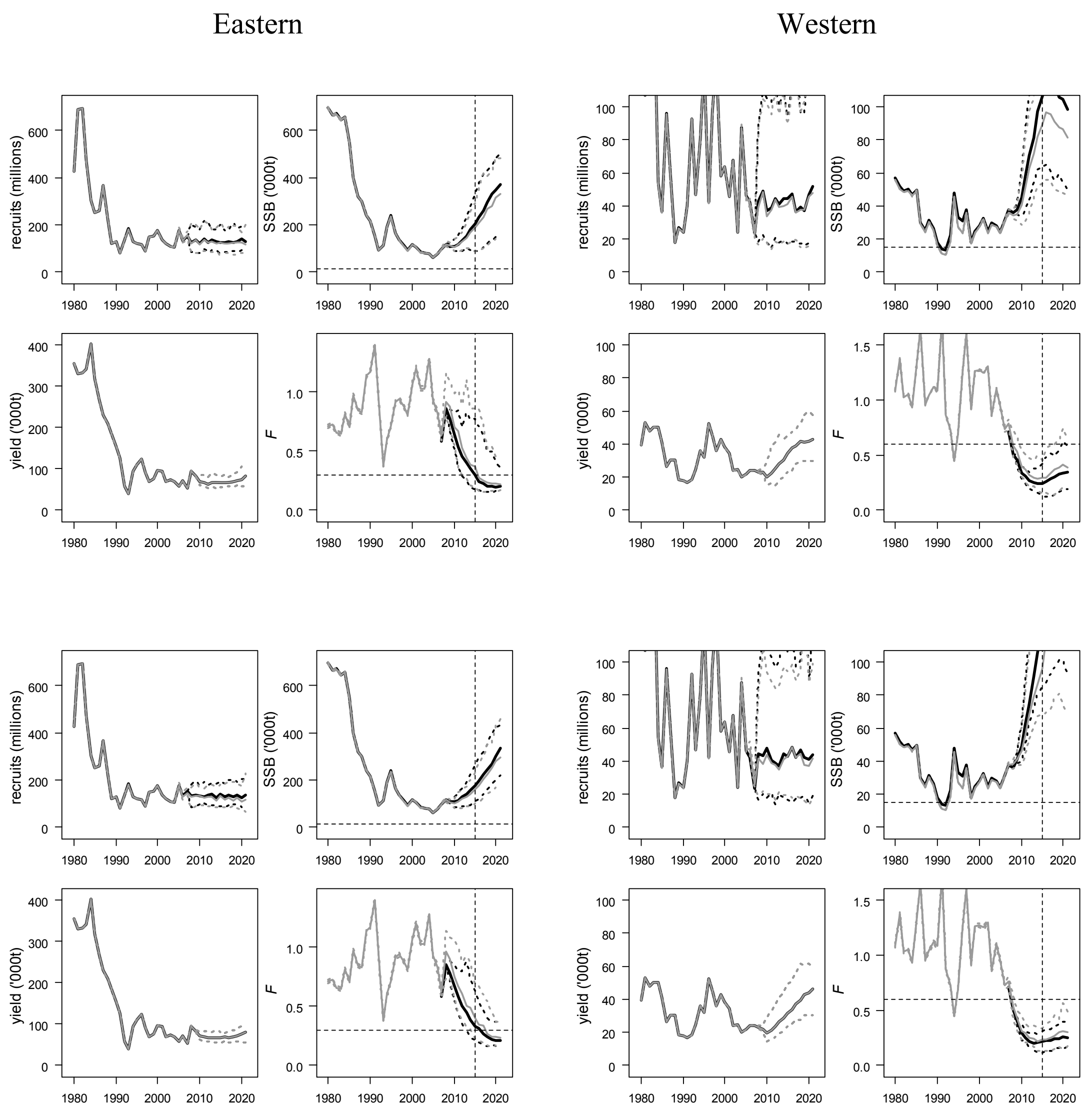


Figure G.18 Two upper panels is scenario 1 from Table G10 with no migration, while the two lower Panels show results of the migration patterns under scenario 6 in Table X.1. See figure explanations in Figure X.5

ANNEX H: ESTIMATES OF FMSY FOR THE WESTERN BALTIC COD

Current candidate F_{msy} for Western Baltic cod is 0.24, that corresponds to F_{max} from yield per recruit analyses (ICES WGBFAS 2010). F_{max} is well-defined for this stock and was not found to be sensitive to changes in cannibalism (affecting fishing mortality on younger ages) or mean weight at age.

Additional analyses were conducted to estimate Fmsy using the ADMB module as used by the ICES WGNSSK. The model assumes a single species harvest scenario with no density dependent variation in growth and mortality rates at high stock abundance. Input data was taken from the latest assessment, weight at age in the catch and in the stock were used as average for the time-period when data by individual years are available (1985-2009 for weight and 1992-2009 for maturity). Selection pattern was used as average for the last 3 years. Recruitment was estimated from Ricker, Beverton-Holt and the smoothed Hockey stick stock -recruitment curves fitted to the data (Figure H1).

The analyses resulted in Fmsy estimates at 0.21 and 0.26 assuming Beverton-Holt and Hockey-stock stock-recruitment functions, respectively, and at 0.55 assuming Ricker stock-recruitment curve (Figures H2-H4; Table H1). All analyses resulted in very high corresponding biomasses, SSB between 300 -1200 kt, which is ten to forty times the level of current SSB.

Consequently the definition of Fmsy for the Western Baltic cod is dependent on whether it is considered that recruitment will be reduced or either remain constant or continue to increase at high stock abundance. Consequently a definitive Fmsy value cannot be determined based on the current information. On the basis of the three models that have equally plausible fits to the stock and recruit estimates (Table H1) fishing mortalities in the range of 0.21-0.55 could be considered consistent with Fmsy for the Western Baltic cod.

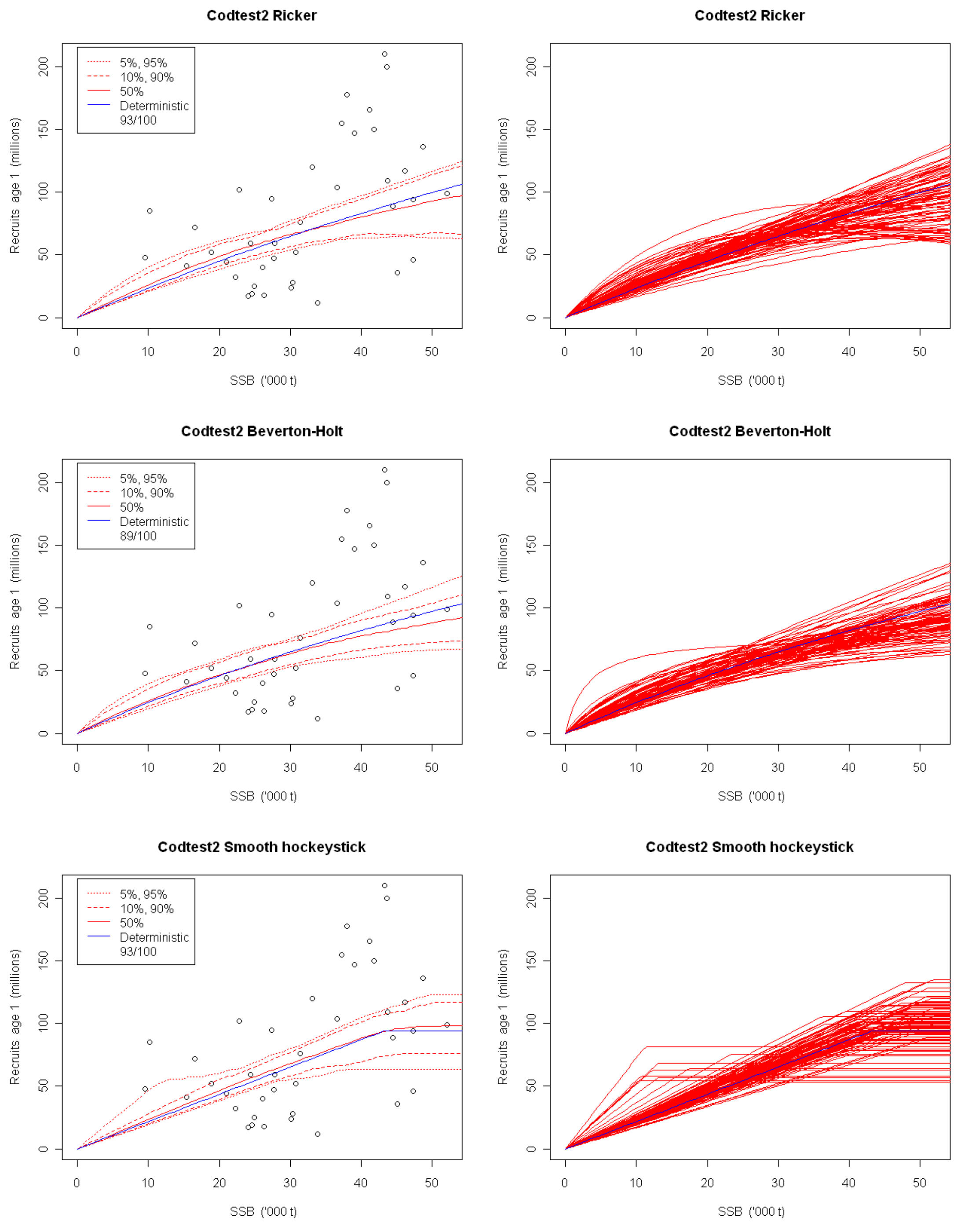


Figure H1. Stock recruitment relationships fitted to the data of the Western Baltic cod.

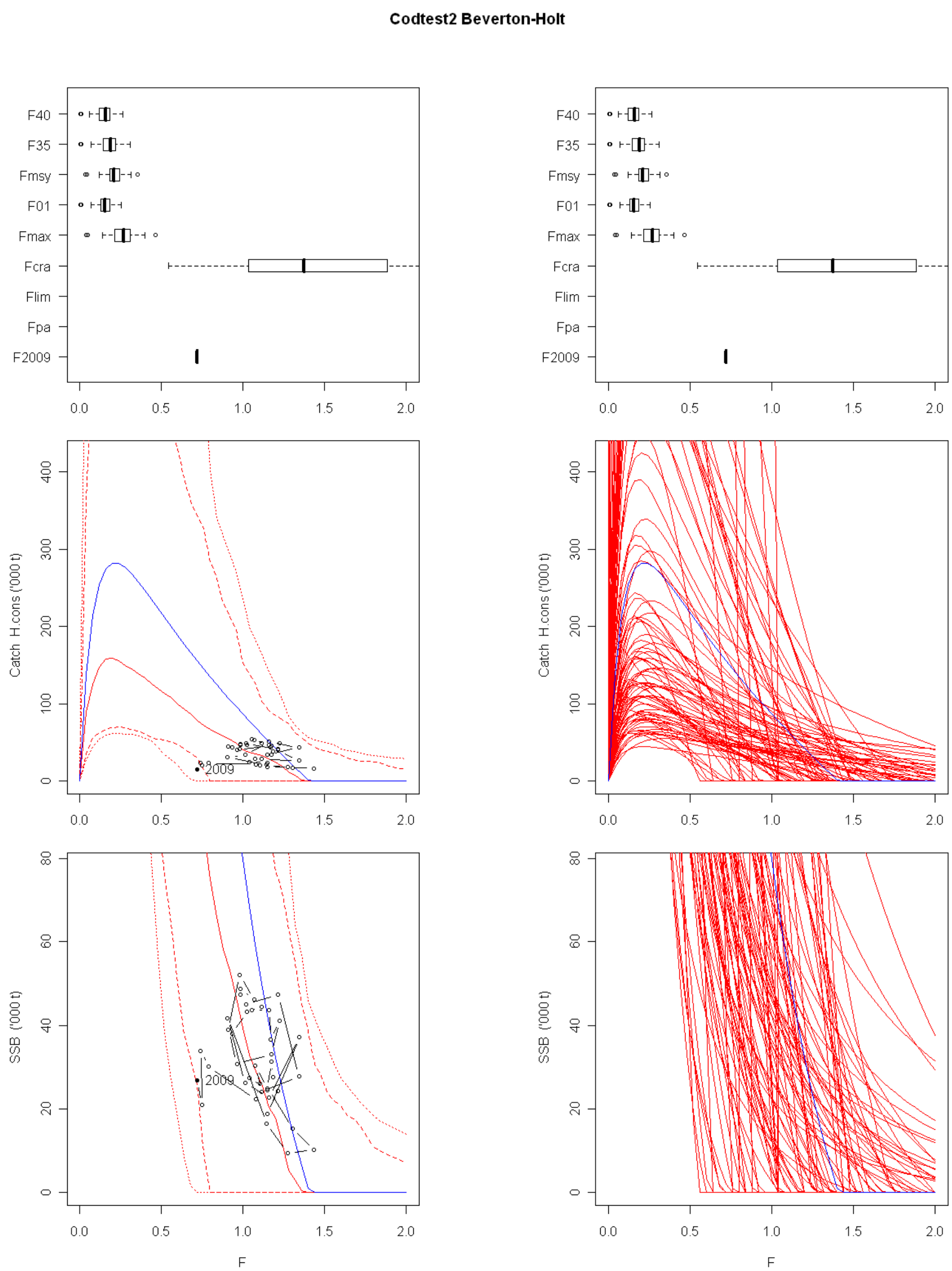


Figure H2. Results of simulations estimating Fmsy using Beverton-Holt stock-recruitment relationship.

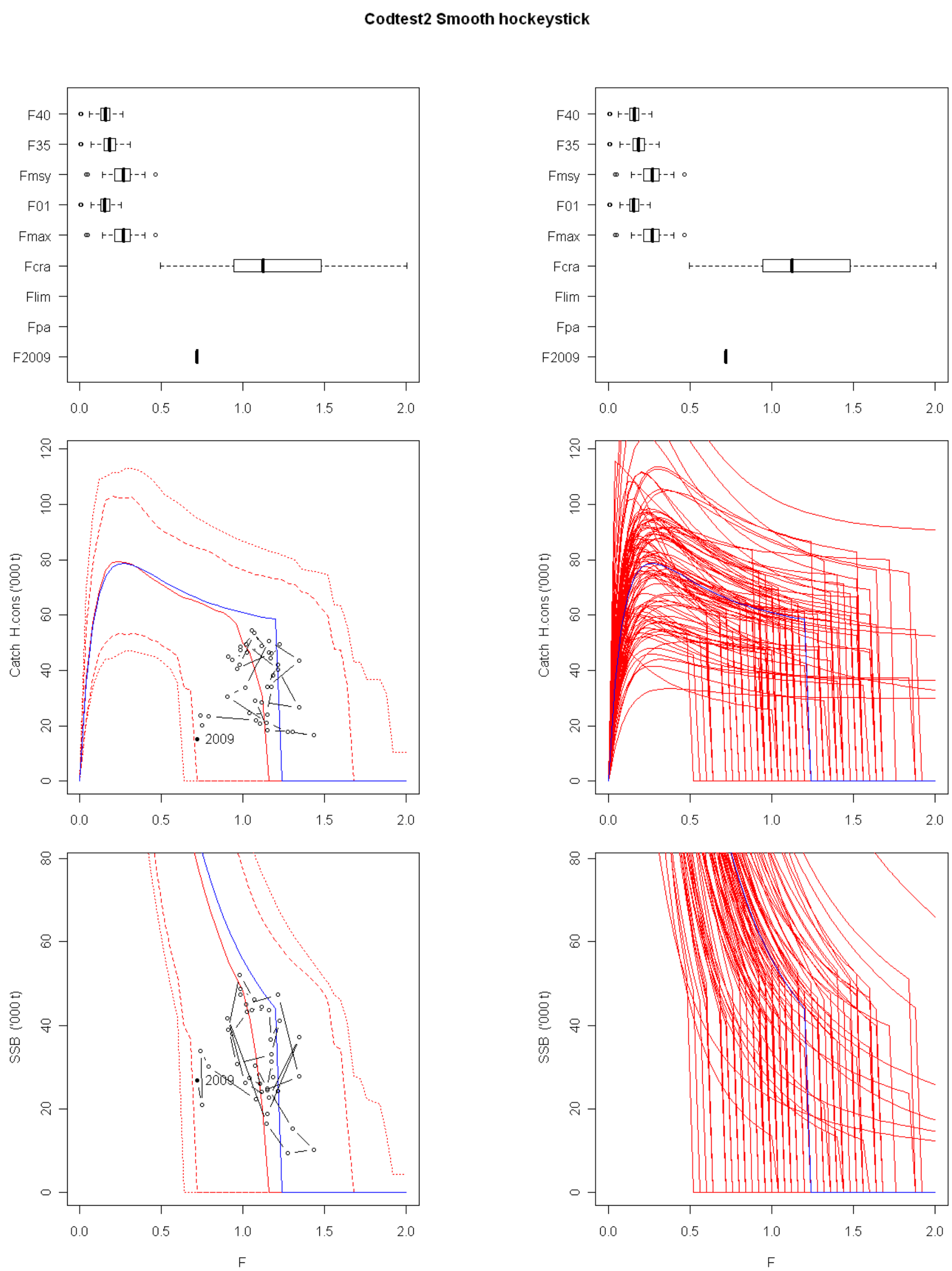


Figure H3. Results of simulations estimating Fmsy using hockey-stick stock-recruitment relationship.

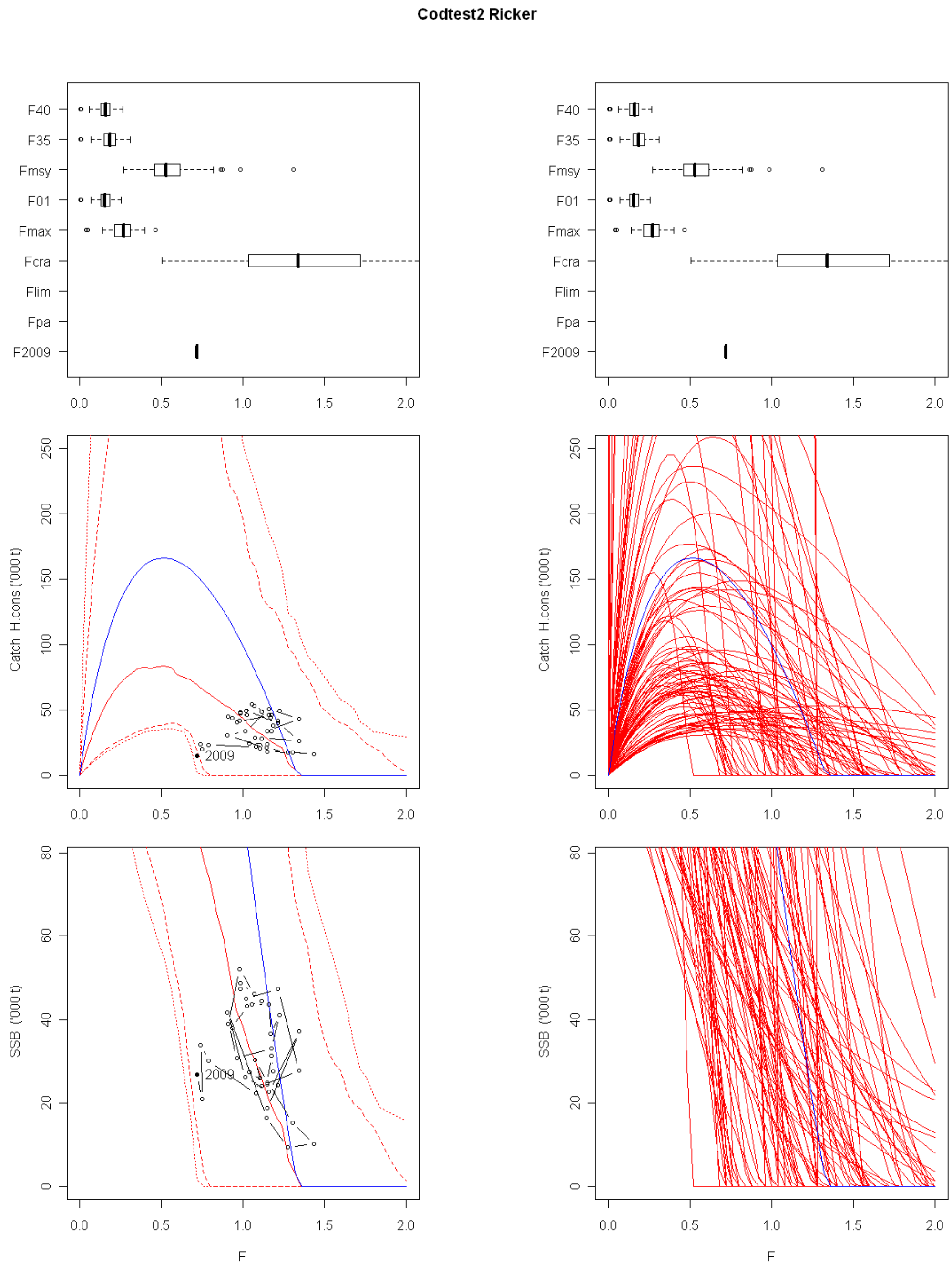


Figure H4. Results of simulations estimating Fmsy using Ricker stock-recruitment relationship.

Table H1. Results of the analyses estimating Fmsy and Bmsy applying different stock recruitment relationships.

Ricker

93/100 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alph	ADMB Bet	Unscaled A	Unscaled E	AICc
Determinis	1.33445	0.515751	305.484	166.271	0.783508	0.153412	2.44224	0.004037	88.8287
Mean	1.438909	0.552903	910.7531	464.4841	0.759618	0.38221	3.067836	0.010058	90.75632
5%ile	0.72384	0.362636	44.99302	38.55172	0.617758	0.033414	2.14136	0.000879	88.93574
25%ile	1.03234	0.456502	98.9022	63.7253	0.682553	0.158938	2.47876	0.004183	89.1534
50%ile	1.33657	0.5262	152.181	85.5734	0.760614	0.317369	2.77934	0.008352	89.9457
75%ile	1.71737	0.614879	298.111	164.217	0.821895	0.488086	3.23797	0.012844	91.7064
95%ile	2.3552	0.806724	1455.912	794.119	0.917741	1.0182	5.295332	0.026795	94.6362
CV	0.409283	0.285303	4.569955	4.523251	0.127588	0.795298	0.306264	0.795298	0.024214

Beverton-Holt

89/100 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alph	ADMB Bet	Unscaled A	Unscaled E	AICc
Determinis	1.40852	0.216119	1230.49	282.46	0.265371	1.28969	382.868	146.678	88.768
Mean	1.550359	0.209089	4572.597	956.7754	0.492465	1.377059	1127.717	468.7746	90.23741
5%ile	0.690994	0.134437	252.3832	63.15362	0.050865	1.116628	95.8885	19.8449	88.82096
25%ile	1.03378	0.182542	418.408	99.8187	0.187536	1.2641	146.154	37.4865	89.0484
50%ile	1.37399	0.209344	680.764	159.662	0.49627	1.35097	204.731	65.5835	89.6729
75%ile	1.88299	0.241449	2102.22	390.524	0.69517	1.47559	541.774	194.677	90.8676
95%ile	2.982144	0.284416	6943.202	1367.28	1.059602	1.710414	2269.26	957.8216	93.55822
CV	0.481006	0.242231	4.132968	4.052703	0.654125	0.124266	3.666493	3.71062	0.017834

Smooth hockeystick

93/100 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alph	ADMB Bet	Unscaled A	Unscaled E	AICc
Determinis	1.21835	0.268211	277.905	78.8082	0.407557	1.35115	1.0897	43.3077	88.7289
Mean	1.24107	0.260466	337.8024	80.70811	0.468093	1.298444	1.251559	41.61837	90.68172
5%ile	0.610083	0.147297	139.8766	49.45914	0.358831	0.40877	0.959422	13.10212	88.88652
25%ile	0.942878	0.211855	213.648	63.5074	0.398267	1.23332	1.06486	39.5311	89.0826
50%ile	1.12318	0.266263	267.069	80.2316	0.433647	1.35543	1.15946	43.445	89.6624
75%ile	1.47764	0.305266	371.546	93.6821	0.462332	1.49519	1.23615	47.9245	91.2647
95%ile	1.933576	0.373869	589.7656	114.4512	0.873712	1.604818	2.33608	51.43836	95.43428
CV	0.459339	0.269983	1.032781	0.283449	0.344137	0.242222	0.344137	0.242222	0.025777

Per recruit

	F35	F40	F01	Fmax	Bmsypr	MSYpr	Fpa	Flim
Determinis	0.193559	0.162994	0.158693	0.268211	2.94438	0.834965		
Mean	0.179872	0.151953	0.152664	0.260467	3.513647	0.833231		
5%ile	0.103483	0.085639	0.086525	0.147297	1.467992	0.588966		
25%ile	0.148182	0.125158	0.12757	0.211855	2.32409	0.680461		
50%ile	0.183633	0.155308	0.152257	0.266263	2.66972	0.833328		
75%ile	0.215297	0.182301	0.180564	0.305266	3.71654	0.924249		
95%ile	0.26555	0.223739	0.21796	0.373869	5.747462	1.232768		
CV	0.308039	0.31034	0.283736	0.269983	0.965884	0.23191		

Annex I: Medium term projections evaluation of the effects of the management plan on the stocks

Introduction

Associated to the meeting there has been performed Management Strategy Evaluation (MSE) and simulation of consequences, robustness and sensitivity of the Baltic cod multi-annual management plan to achieve stock recovery within the medium term for both the Western and Eastern Baltic cod stocks. This has been done with purpose of evaluating if and in given case when the targets of the management plan will be achieved based on a row of stock, stock assessment and management pre-conditions.

The management plan evaluations for the Eastern Baltic cod is based on results given in the scientific peer reviewed papers Bastardie *et al.* (2010a,b) using input data from the ICES WGBFAS 2008 assessment which has been updated in the WKROUND 2009 benchmark assessment (Bastardie *et al.*, 2010a). Actual stock conditions has changed compared to the evaluated conditions for the Eastern Baltic cod stock as the recruitment has been higher in recent years compared the used low recruitment level in the presented evaluations. This means that the targets of the management plan have been achieved faster than predicted under a low recruitment scenario for Eastern Baltic cod. The presented evaluation results for this stock show, consequently, that the management plan targets would also have been reached with high likelihood in the medium term if there had only been consistent low recruitment in this period.

For the Western Baltic cod the management plan evaluation has also been done according to the methods and evaluations given in Bastardie *et al.* (2010a), but is in present context up-dated with input data and results from the ICES WGBFAS 2010 assessment.

Approach

The multi-annual management plan for Baltic cod stock recovery is a F-adaptive regulation system with a gradual reduction of F by 10% per year for both stocks translated into a total reduction in TAC and Effort (allowing catches even if below the precautionary limits). The Baltic cod 2008 management plan includes a number of key actions:

• Set a TAC that will result in a 10% reduction in the fishing mortality rate in each year of application compared to the fishing mortality rate estimated for the previous year (EU Commission, 2007; Article 6.1.a).

• Where the fishing mortality rate for one of the cod stocks concerned has been estimated to be at least 10% higher than the minimum (or target) fishing mortality rate (i.e. 0.3 or 0.6 for Eastern and Western Baltic cod stock, respectively), the total number of active fishing days shall be reduced by 10% compared to the total number of allowed fishing days in the current year (EU Commission, 2007; Article 8.4).

• Where the fishing mortality rate for one of the cod stocks concerned has been estimated to be less than 10% higher than the minimum fishing mortality, the total number of active fishing days E shall be reduced by the actual (0–10%) percentage. (EU Commission, 2007; Article 8.5).

• The TAC values are constrained to remain within an interval of ±15% avoiding large annual fluctuations from 1 year to the next, except if F is larger than 0.6 (Eastern Baltic cod stock) or 1.0

(Western Baltic cod stock), in which case the TAC may be reduced by more than 15%.

The reductions in fishing mortality are implemented as effort reductions supplemented by TACs. In relation to the performed MSE the interpretation of the rules can be presented as follows:

$$\bar{F}_y = \bar{F}_{y-1} \times \frac{E_y}{E_{y-1}}$$

$$\bar{F}_{y+1} = \bar{F}_y \times 0.9 \quad \text{if} \quad \bar{F}_{y-1} \geq F_{\text{target}} \times 1.1$$

$$E_{y+1} = \begin{cases} E_y \times 0.9 & \text{if} \quad \bar{F}_{y-1} \geq F_{\text{target}} \times 1.1 \\ E_y \times \dfrac{F_{\text{target}}}{\bar{F}_{y-1}} & \text{if} \quad F_{\text{target}} < \bar{F}_{y-1} < F_{\text{target}} \times 1.1 \end{cases}$$

In the evaluation, the effort reduction was implemented such that the F used for calculation of TAC in the coming year in the simulation was given by the following harvest control rule (HCR):

$$\bar{F}_{y+1} = \bar{F}_{y-1} F_{\text{mult}} F_{\text{mult}}$$

$$F_{\text{mult}} = \begin{cases} 0.9 & \text{if} \quad \bar{F}_{y-1} > F_{\text{target}} \times 1.1 \\ 1.1 & \text{if} \quad \bar{F}_{y-1} < F_{\text{target}} \times 0.9 \\ \dfrac{F_{\text{target}}}{\bar{F}_{y-1}} & \text{if} \quad F_{\text{target}} \times 0.9 < \bar{F}_{y-1} < F_{\text{target}} \times 1.1 \end{cases}$$

The basis of the MSE is a stochastic simulation and modelling with a management strategy evaluation framework developed in FLR (Bastardie, Nielsen, Kraus, 2010b; www.efimas.org). The approach covers scenario evaluation by stochastic simulation of the relative performance of different management options against various sources of uncertainty, such as errors in data collection, used assessment model and settings, and in the implementation of the plan. The present evaluation covers partly an exclusively stock based approach (Bastardie, Vinther Nielsen, Ulrich, Paulsen, 2010a) and a combined fleet and stock based approach (Bastardie, Nielsen and Kraus, 2010b).

The framework comprises two main elements:

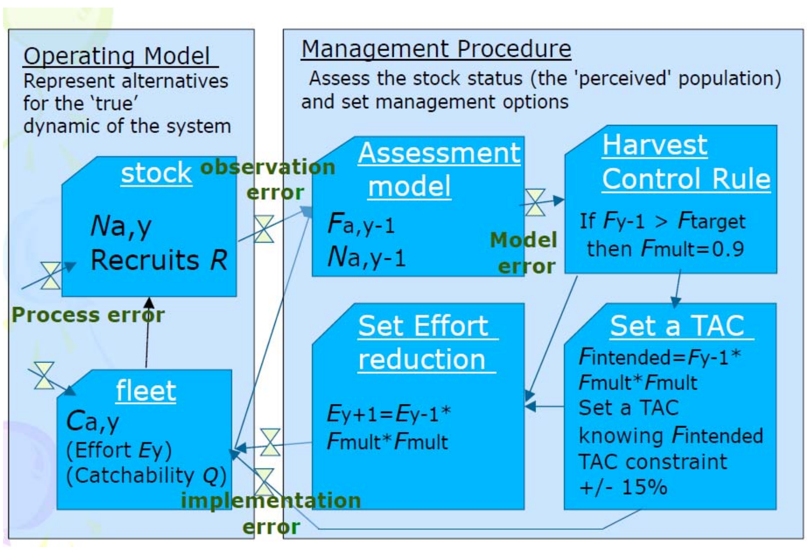
- The Operation Model, OM (e.g. plausible alternative population states, e.g. different SSB-R-relationships, dynamics over time, etc.)
- The Management Procedure, MP (e.g. combination of simulated data, the stock assessment and resulting percieved status of the stock, the management model such as the HCR in the management plan

The MSE framework concept is testing (population dynamic and management) alternatives and scenarios by:

- …simulating forward the 'true' population abundance and yield/fishing mortality (operating model) in a time full feedback loop incorporating the management plan (management procedure), i.e. there is a cyclic full feed-back of management decisions from the MP to the OM (stock assessment)

- …measuring performance criteria (in terms of probability) to reach management targets (evaluated in terms of probability of F is below limit reference points in the terminal year of the simulation (2020/2030) or in the medium term (2015))
- …stochastic simulations to evaluate the sensitivity and robustness against different sources of uncertainties (process, observation, model and implementation errors)
  - Process error (including random variation in recruitment)
  - Observation error (including errors on data collection and collation on CPUE indices for tuning fleets; catch at age matrix e.g. mis-reporting, age reading differences, etc)
  - Assessment or model error (e.g. imperfect perception of the stock because of a particular model or model setting)
  - Implementation or management error (e.g. over-catching the TAC, mis-reporting of catches, discrepancy between scientific advice and the managers final decision)

The procedures for MSE of the Baltic cod management plan can be summarized as follows:



The MSE procedure covers the following general steps:

1 - The assessment model estimates population numbers N-at-age and F-at-age from the last year in the assessment, i.e. yearly-based stock assessment using extended survivor analysis;

2 - At each year y, the OM projects forward the true N-at-age from the assessed initial population (using a survival equation applying the F determined from the HCR and predicting each year a recruitment from a stochastic SSB-R-relationship);

3 - At each year y, the stock is assessed from catch at age up to the current year using information on the true (perfect) population calculated backward from Ny-1 as observed (with possible added observation and model errors);

4 - At year y, a short term forecast (using geometric mean recruitment and average exploitation pattern) is run to apply the HCR from the management plan to decide on F (Fy-1 multiplied with 0.9 or 1.1 or…);

5 - At year y, a TAC is set for the next year knowing the intended F and the forecasted population;

6a - Stock based modeling (both stocks): At year y, the TAC is converted into F in the operating model (Baranov catch equation using y-1 exploitation pattern and TAC=catch) and later used to up-date the population (with added implementation error or bias). TAC is then constrained to ±15%;

6b - Fleet based modeling (only for Eastern Baltic cod): At year y, the annual TAC is converted into split qouta shares per country according to the relative stability and then divided into partial Fs per fleet, area, season, etc. in the operating model.

Further description of the methodology used for the MSEs can be found in the published scientific peer reviewed papers Bastardie *et al.* (2010a) for the stock based MSE and in Bastardie *et al.* (2010b) for the combined stock- and fleet-based MSE.

Input data: Information on which the MSE are based upon

The management plan evaluations for the Eastern Baltic cod is based on results given in the scientific peer reviewed papers Bastardie *et al.* (2010a,b) using input data from the ICES WGBFAS 2008 assessment which has been updated in the WKROUND 2009 benchmark assessment (Bastardie *et al.*, 2010a).

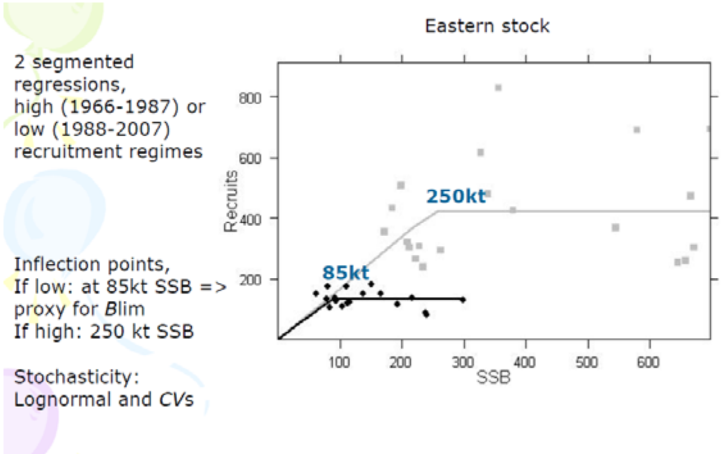
For the Western Baltic cod the management plan evaluation has also been done according to the methods and evaluations given in Bastardie *et al.* (2010a), but is in present context up-dated with input data and results from the ICES WGBFAS 2010 assessment.

The landings are from logbooks and discards from observers according to ICES assessments, stock availability from the BITS survey (fleet based evaluation), and the data on commercial tuning fleets from the ICES assessments. The maturity and mean weight at age are averages for 2005-2007 from the assessments (ICES WGBFAS, 2008; ICES WGBFAS, 2010; ICES WKROUND, 2009; Bastardie *et al.,* 2010a,b).

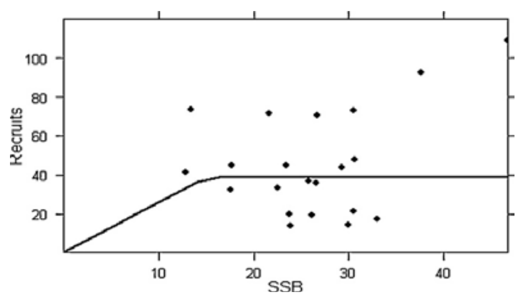
Stock-recruitment data used is based on SSB-R: Stochastic segmented regression with errors in the simulations. Deterministic recruitment is calculated from the Hockey Stick Stock-Recruitment

(SSB-R-) relationship, and the stochastic recruitment is then obtained by adding errors from a log-normal distribution with a Coefficient of Variance (CV) corresponding to the one estimated for the historical recruitment.

Eastern Baltic cod, low recruitment scenario used in the MSE (1988-2007):



Western Baltic cod, low recruitment scenario used in the MSE (1986-2007), resulting in a fixed inflection point of 15 kt corresponding to a proxy for Blim:



Results for Eastern Baltic Cod:

The following scenarios were evaluated under the MSE for Eastern Baltic cod under a low recruitment situation:

- Different model errors (shrinkage in assessment model, XSA)
- Different implementation errors (potential mis-reporting of catch and effort of 10%)
- Stock based vs Stock-Fleet Based MSE, i.e. two different management procedures with TAC-TAE combined vs TAE alone

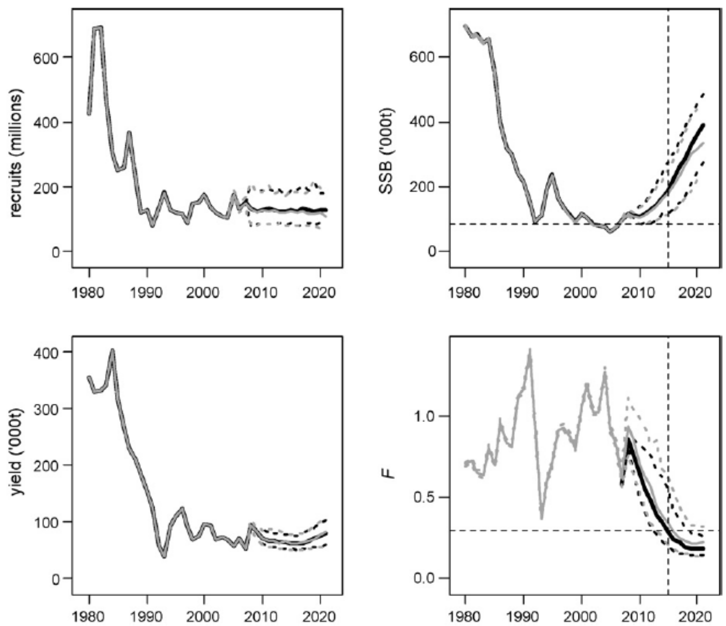


Figure I.1. (From Bastardie *et al.*, 2010a). Eastern Baltic cod. Times series of recruits, SSB, yield and F4–7. Observation Error on CPUE-indices: CV_InE=0.3. Observation Error on Catch-at-Age Matrix: CV_CaE=0.15. **Implementation Error: CV_IE=0.0. Stochastic low recruitment.** Black: OM; Grey: MP). Assessment (XSA) **Model Error: XSA shrinkage=0.5.** Start Year =2009, End Year=2020. Historic part: 1980–2007; projection part: 2008–2022; OM in black; MP in grey; median; dotted lines: 5–95% percentiles. Horizontal dashed lines give reference targets (F = 0.3; SSB = 85 kt). Vertical dashed line indicates the mid-point of the projected time horizon (2015).

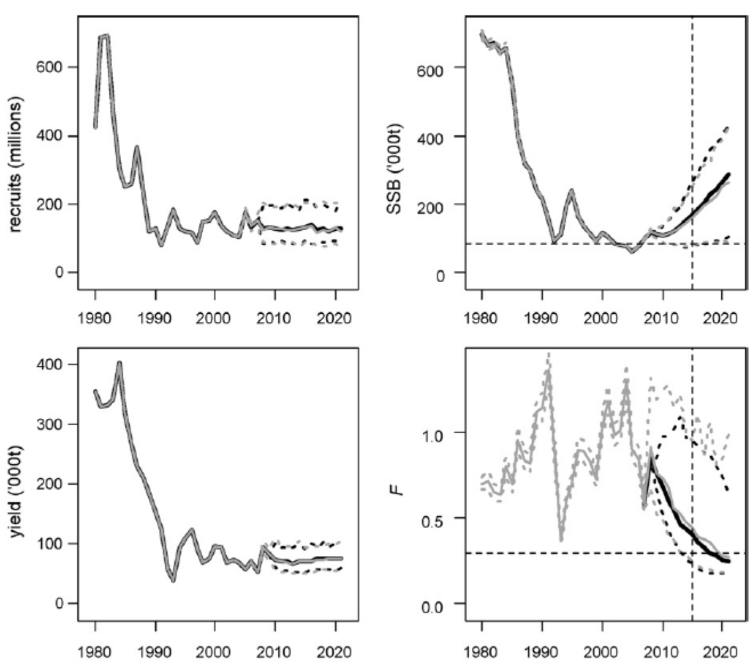


Figure I.2. (From Bastardie *et al.*, 2010a). Eastern Baltic cod. Same as Figure I.1, but with **Model Error: Shrinkage=2.0 (corresponding to very low shrinkage used in the assessment).**

With respect to sensitivity to changed implementation error there has been tested a scenario for Eastern Baltic cod with introduction of 10 % potential landing mis-reporting corresponding to an Implementation Error: CV_IE=0.1 compared to CV_IE=0.0, i.e. TAC # reported catches.

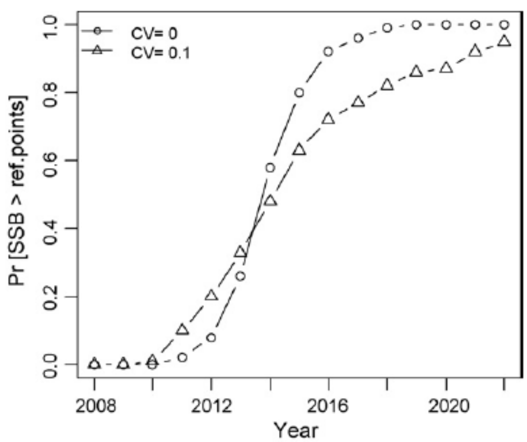


Figure I.3. (From Bastardie *et al.*, 2010a). Eastern Baltic cod. Sensitivity of the effect of the implementation error on the probability of the SSB being above the 160 kt reference points in SSB. All other sources of errors are null.

Actual stock conditions has changed compared to the evaluated conditions for the Eastern Baltic cod stock as the recruitment has been higher in the most recent years compared the used low recruitment level in the presented evaluations. According to the 2010 ICES WGBFAS assessment the target of F below 0.3 has already been reached from 2008 which can mainly be attributed to recent high recruitment. This means that the targets of the management plan have been achieved faster than predicted under a low recruitment scenario for Eastern Baltic cod. The presented evaluation results for this stock show, consequently, that the management plan targets would also have been reached with high likelihood within the medium term period (2015-2020) under a low recruitment situation, i.e. if there had only been consistent low recruitment in this period.

These results indicate that the management target of F=0.3 would have been achieved with more than 50 % probability (median=50%) by 2015 in the medium term prediction even under low recruitment within the scenario of extensive shrinkage used in the assessment (Shrinkage=0.5; actual shrinkage for the XSA used in the ICES assessment in 2010 is 0.75).

The plan is sensitive to change in the assessment settings with respect to release on shrinkage which will delay the period before the target is reached, but not the trend. Under low recruitment the target would not have been achieved until 2018.

The plan is also sensitive to introduction of an implementation error, i.e. potential mis-reporting on landings and effort. Under low recruitment, the plan would have been delayed in reaching its targets even in case of only 10% under-reporting occurs or stochastic mis-reporting (mis-reporting of landings and effort), but the trend would not change.

As the fishing pattern for Baltic cod varies considerably according to effort allocation between areas and seasons (targeting behavior, fishing closures) and with respect to selectivity (gears, mesh sizes) between national fleets (fisheries) the stocks are exposed to spatial dynamics and seasonal targeted fishing behavior (Bastardie *et al.*, 2010b). Therefore, it is relevant to compare the sensitivity and robustness of the MSE under a simple stock based evaluation with a complex stock and fleet based evaluation with a different exploitation pattern. In the complex evaluation the fleet based model (OM) accounts for heterogeneity in fishing practices, effort allocation spatially and between fleets and enable testing for possible fleet adaptation on management success.

The differences of the combined stock and fleet based evaluation to the stock-based evaluation are:

1 - the modeling of effort is explicit (do not assume constant fishing pattern as in the simple stock-based operating model, OM) by fleet, so that the overall stock-F is an aggregation of fleet-specific Fs, knowing fleet specific catchability (here assuming a linear relationship between F and E (effort), i.e. constant catchability per fleet over time) and spatio-temporal allocation of fishing effort

2 - the age-structured population is spatially explicit and age-specific migration occur within the year

3 – Consequently, the F-stock is the conjunction between the various spatio-temporal fleet activities and the variable spatio-temporal stock availaibility (the latter from surveys)

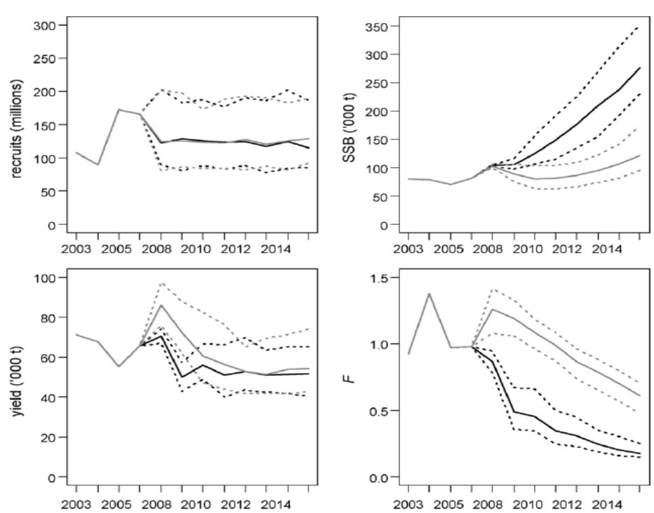


Fig. I.4. (From Bastardie et al., 2010b). Eastern Baltic cod. Comparison of the simulated time series for N= 100 iterations for the Eastern cod recruits, SSB, yield and F4–7 for the baseline scenario (CVInE =0.3; CVCaE =0.15; no implementation error; stochastic low recruitment) under the fleet-based version of the model **under two different management procedures** (**in black, OM applying the agreed plan combining the Effort control with the TAC system** vs. **in grey, OM applying the effort control alone**). 5–95% percentiles in dotted lines and medians in solid lines.

The performance of the plan is more pronounced taking into account a dynamic exploitation pattern. The effort control is demonstrated to be more efficient when supplemented with a TAC and avoids un-intended effects from fishery responses, e.g. spatial effort re-allocation. Effort control reduce the effect of possible misreporting.

The results of the combined stock and fleet based evaluation compared to the stock based evaluation also indicate (Bastardie *et al.,* 2010a,b) that the latter with its changed exploitation pattern leads to higher reductions in F and no significant change in management robustness.

The management plan is likely to be robust to possible changes in the fishery given plausible fleet responses.

Results for Western Baltic cod

For the Western Baltic cod the management plan evaluation is also carried out according to the methods and scenarios given in Bastardie *et al.* (2010a), but is in present context up-dated with input data and results from the latest ICES WGBFAS 2010 assessment.

The assessment model used is the MSE evaluation is the XSA model which is implemented in FLR. In the latest assessment in 2010, ICES WGBFAS has (based on the 2009 benchmark assessment under ICES WKROUND 2009) shifted to the SAM assessment model to base the final assessment upon. Below in Figure I.5 is shown the perception of stock SSB and fisheries mortality at age as well as recruitment at age 1 as a comparison between the final XSA (in FLR) and SAM model runs from the ICES WGBFAS 2010. As it can be seen, the mean stock is the same in general and also for the terminal assessment year (i.e. for the initial stock in 2009 used in the MSE), however, there are high confidence intervals for SSB in the SAM model. The perception of F at age is also similar between the two models, and also for the terminal assessment year.

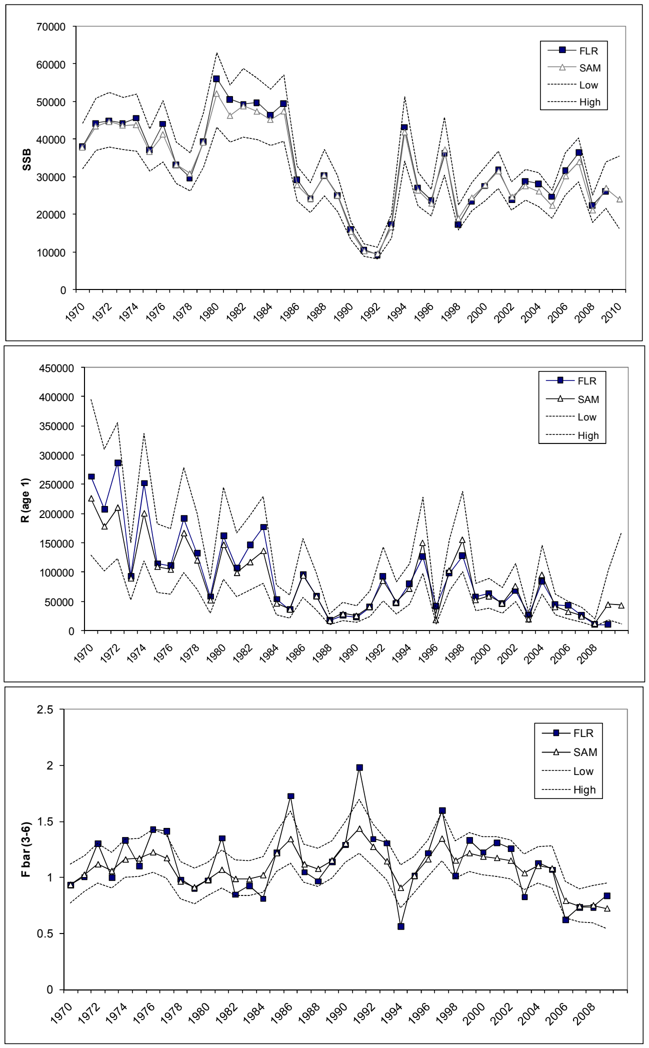


Figure I.5 Cod in SD 2224. Comparison between SAM and XSA (in FLR) runs for SSB, recruitment at age 1 and F bar. Dotted line indicate confidence intervals for the SAM model.

The MSE scenarios evaluated in the MSE related to SGMOS 10-06n cover efficiency of the management plan according to different F-targets. The current target in the plan is F=0.6 while a more recent F_{MSY} estimate is F=0.24 for Western Baltic cod (see section on F_{MSY} considerations). The different F-targets are evaluated according to sensitivity to two levels of implementation error, i.e. none and 10% mis-reporting (Figure I.6).

Furthermore, the sensitivity of the MSE in relation to different levels of TAC constraints in the management plan has been tested, i.e. a ±15% TAC constraint compared to a ±50% TAC constraint under both F-targets of 0.6 and 0.24, respectively. These scenarios are tested under the level of assessment model settings with shrinkage=0.5 (actual shrinkage used in the XSA assessment is 0.75), and with constant implementation error of 0.1 (Figure I.7).

In general, it should be emphasized that the evaluation results and the chance of success of the 2008 management plan is dependent on a row of pre-conditions and assumptions on sources of uncertainties and their magnitudes. First of all, the targets of the plan should reflect the stock dynamics. As shown in previous chapters the F-target of 0.6 for the Western Baltic cod is probably too high. Another major condition and impact is the initial population number at age used from assessment and the level of fishing mortality assessed at the start of the period coming from the ICES assessment model, i.e. model error according to the model used. The 2008 management plan has been shown to be very sensitive to the initial assessment providing initial F and N estimates (assessment errors) (Bastardie *et al.*, 2010a). There is a risk of initiating the gradual F reduction procedure with a high targeted F (if the initial F is high) while the stock is presently overexploited (low SSB from high F). It should be noted that the initial population and F is similar (means) between the XSA and SAM assessment models (ICES WGBFAS, 2010).

The biological parameters are assumed to be constant on the long term basis in the MSE. It is apparent that the strongest factor controlling the magnitude of the success of the management plan is the level of recruitment (Bastardie *et al.*, 2010a). The projections have assumed that recent low levels will continue. The low recruitment regime tested did not prevent stock recovery. However, the most recent years cod recruitment in the Western Baltic Sea has been below the average recruitment even in the low recruitment regime during 1986-2007. There is also indications of very recent changes in mean weight at age and maturity compared to the averages used for 2005-2007 in the simulations.

In general, the plan has been shown to be robust against uncertain data and various degrees of errors in the perception of the true stock dynamics (observation errors), and the assessment model shrinkage settings did not change the trends but could delay the period before the targets are reached. It is a condition that the observation and assessment errors added or generated in the management procedure remain with the same order of magnitude as that tested. Finally, the effort reduction in the intermediate year needs to be fully complied with and the exploitation pattern should remain constant.

The results of the MSE with up-dated data indicate that the current management target of F=0.6 under the long term management plan will be achieved with more than 50 % probability (median) by 2015 in the medium term prediction even under an average low recruitment situation for the Western Baltic area (recruitment period included is 1986-2007). A potential management target of F=0.24 will also be achieved with more than 50% probability within the medium term, but with 1 year delay, i.e. by 2016. This is the case also in a situation where there is 10 % mis-reporting on landings, i.e. with a implementation error on 0.1. (Figure I.6). However, it should in this context be emphasized that the simulated projections are based on assumptions on constant, average biological conditions, e.g. recruitment, for the Western Baltic cod in the projected period as discussed above as well as based on correct initial stock levels simulated (N and F).

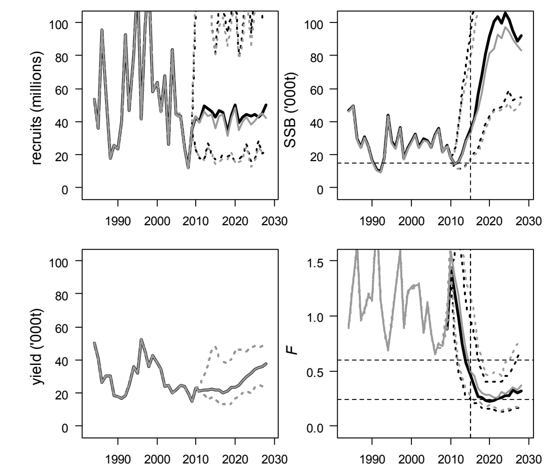
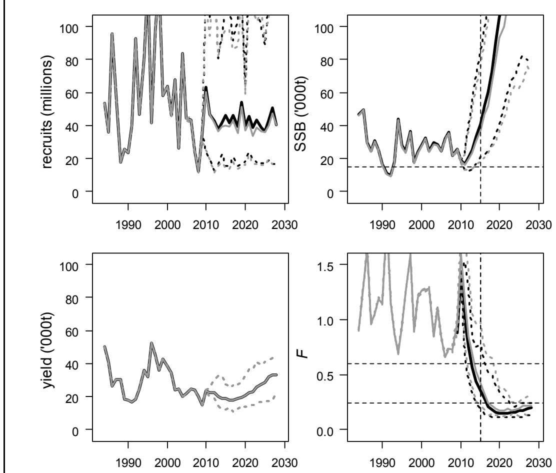
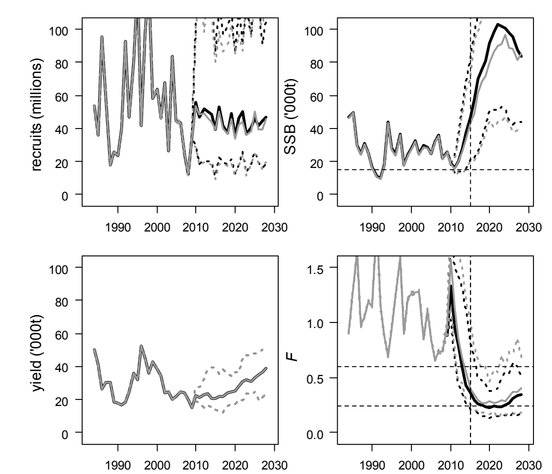
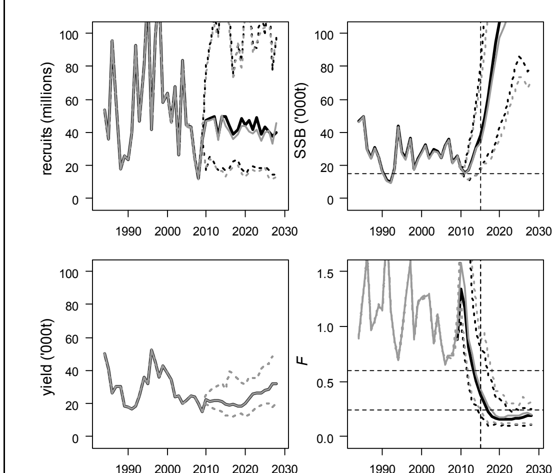
	F target= 0.6	F target= 0.24
IE=0.0	a) 	b) 
IE=0.1	c) 	d) 

Figure I.6 Western Baltic cod. MSE evaluating the management plan according to different F-targets and levels of implementation error. Settings: Panel a) **Ftarget at 0.6** (long-term man. plan), CV_InE=0.3, CV_CaE=0.15, **CV_IE=0.0**, Start=2010, End=2030; Panel b) **Ftarget at 0.24**, CV_InE=0.3, CV_CaE=0.15, **CV_IE=0.0**, Start=2010; End=2030; Panel c) **Ftarget at 0.6** (long-term man. Plan), CV_InE=0.3, CV_CaE=0.15, **CV_IE=0.1,** Start=2010, End=2030; Panel d) **Ftarget at 0.24**, CV_InE=0.3, CV_CaE=0.15, **CV_IE=0.1**, Start=2010, End=2030; **(All panels: TAC Constraint corresponding to 10% F-reduction, max TAC change +/-15% and a Model Error: XSA shrinkage=0.5.).**

Historic part: 1980–2009; projection part: 2008–2030; OM in black; MP in grey; dotted lines: 5-95% percentiles and median. Horizontal dashed lines give reference targets (F = 0.6 and 0.24; SSB =15 kt). Vertical dashed line indicates the mid-point of the projected time horizon (2015).

	e)	f)

The plan is sensitive to change and release in the TAC constraint (Figure I.7) and the ±15% TAC constraint is a restrictive driver in the management plan. In the situation of ±15% TAC constraint, F will stay low around 0.25 also after F-targets have been reached in 2015 both under the F-target of 0.6 and 0.24 situation, while F will be higher and closer to 0.6 when the TAC constraint is released to be ±50% under a F-target=0.6 situation.

ANNEX J: SUMMARY OF ECONOMIC INFORMATION BY FLEET SEGMENT

In Total 16 fleet segments were selected for the analysis based on the fraction of the value of Baltic cod by fleet, Most of those fleets with greater than 20% dependency were selected. This covered 885 of cod caught by fleets for which there were data.

Due to lack of area allocation to effort data, no Danish fleet segments could be analysed. For all other EU MS involved in Baltic cod fisheries, data have been made available. One Estonian fleet segment was identified as taking most of the Estonian cod quota but this fleet segment did exceeded the 20% threshold and it was decided that its economic dependency would be small so it was excluded along with the other fleets with low Baltic cod dependency..

For 2002-2003, data from new MS are incomplete as there was no obligation to collect it prior the accession, so the coverage that period is only about 34% . The total volume of cod catches covered by the selected fleets was 54-58% of total cod catches in 2004-2009 recorded in the ICES Advice.

Table J.1 Capacity of analysed segments in 2002-2009, number of vessels

Fishing Techique	Vessel Lenght	Country	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Drift and/or fixed nets	12-24 m	Finland	61	58	57	51	47		18	13
		Poland			170	132	103	91	86	53
		Sweden	48	51	46	50	34	35	27	22
	24-40 m	Latvia	60	60	58	41	36	28	26	23
	Total		***169***	***169***	***331***	***274***	***220***	***154***	***157***	***111***
Demersal trawlers and/or demersal seiners	< 12 m	Germany	16	14	21	14	14	14	14	13
	12-24 m	Germany	91	80	75	72	75	77	72	67
		Poland			141	124	91	93	93	72
		Sweden	160	154	160	149	158	160	108	102
	24-40 m	Lithuania			38	30	24	21	16	14
		Poland			74	48	44	31	25	7
		Sweden	38	35	30	30	27	33	86	89
	Total		***305***	***283***	***539***	***467***	***433***	***429***	***414***	***364***
Vessels using passive gears only	< 12 m	Germany	981	914	908	956	1000	992	960	959
		Poland			770	685	621	584	576	536
		Sweden	752	951	908	880	912	891	825	808
	Total		***1733***	***1865***	***2586***	***2521***	***2533***	***2467***	***2361***	***2303***
Pelagic trawlers	24-40 m	Lithuania						7	8	8
		Latvia	81	83	79	75	72	67	66	60
	Total		***81***	***83***	***79***	***75***	***72***	***74***	***74***	***68***
Grand Total			**2288**	**2400**	**3535**	**3337**	**3258**	**3124**	**3006**	**2846**

Table J.2 Dependency of selected fishing fleets on cod landings (value), 2002-2009

Fishing Technique	Vessel Lenght	Country	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Drift and/or fixed nets	12-24 m	Finland	40%	58%	50%	19%	18%	16%	51%	39%
		Poland			75%	73%	65%	58%	86%	50%
		Sweden	75%	73%	49%	57%	62%	47%	45%	40%
	24-40 m	Latvia	98%	99%	100%	100%	99%	99%	100%	100%
	Total		***84%***	***85%***	***75%***	***75%***	***71%***	***63%***	***79%***	***65%***
Demersal trawlers and/or demersal seiners	< 12 m	Germany	61%	60%	64%	62%	69%	57%	60%	39%
	12-24 m	Germany	40%	30%	36%	37%	31%	32%	30%	57%
		Poland			67%	64%	72%	56%	68%	58%
		Sweden	26%	28%	31%	24%	29%	30%	11%	13%
	24-40 m	Lithuania			69%	81%	93%	90%	88%	85%
		Poland			61%	56%	61%	60%	56%	52%
		Sweden	37%	32%	35%	26%	39%	40%	25%	21%
	Total		***33%***	***30%***	***40%***	***37%***	***40%***	***38%***	***30%***	***31%***
Vessels using passive gears only	< 12 m	Germany	31%	38%	29%	35%	36%	33%	27%	19%
		Poland			40%	41%	48%	34%	37%	43%
		Sweden	51%	51%	42%	40%	39%	36%	36%	27%
	Total		***43%***	***46%***	***39%***	***39%***	***41%***	***35%***	***34%***	***30%***
Pelagic trawlers	24-40 m	Lithuania						15%	31%	12%
		Latvia	20%	14%	14%	12%	20%	25%	14%	21%
	Total		***20%***	***14%***	***14%***	***12%***	***20%***	***23%***	***17%***	***19%***
Grand Total			**39%**	**39%**	**42%**	**38%**	**41%**	**37%**	**32%**	**31%**

Legend	
(orange)	66-100% of landings value coming from cod fishery in the Baltic
(yellow)	33-66% of landings value coming from cod fishery in the Baltic
(green)	<33% of landings value coming from cod fishery in the Baltic

Table J.3 Economic performance of selected cod fishing fleets, 2004-2009

	2004	2005	2006	2007	2008	2009	Av. 2004-2006	Av. 2007-2009	% Change	Av. per vessel 2004-2006	Av. per vessel 2007-2009	% Change
mln Euro, segment total												
INCOME, mln. Eur; Eur/vessel	127,7	128,2	132,5	149,8	171,4	125,1	129,5	160,6	24%	38339	49722	30%
COSTS, mln. Eur; Eur/vessel	129,6	122,2	139,7	139,2	122,1	98,3	130,5	130,7	0%	38649	40069	4%
Energy (fuel) costs	22,1	29,1	28,2	23,0	29,0	14,8	26,5	22,3	-16%	7838	7441	-5%
Repair costs	17,3	22,5	20,0	20,0	20,6	15,0	20,0	18,5	-7%	5910	6199	5%
Variable costs	15,9	13,9	18,5	22,7	11,4	8,3	16,1	14,1	-12%	4776	4725	-1%
Non variable costs	29,1	22,1	41,3	42,3	38,8	36,7	30,8	19,6	-36%	9135	13122	44%
Crew wages	45,1	34,5	31,7	31,3	22,3	23,5	37,1	25,7	-31%	10990	8582	-22%
Derived indicators												
Gross cash flow	13	17	22	40	73	63	17	59	241%	5114	19659	284%
Gross value added	58	52	54	71	96	87	54	84	55%	16104	28241	75%
Employment (Total 1000)	3,49	6,25	6,10	6,04	5,62	4,09	5,3	5,2	-1%	1,6	1,8	12%
Capacity indicators												
Number of vessels	3535	3337	3258	3124	3006	2846	3377	2992	-11%	3377	2992	-11%
Fleet, 1000 kW; kW/vessel	317,5	289,2	276,9	269,5	262,9	238,1	295	257	-13%	87	86	-2%
Fleet, 1000 GT; GT/vessel	73,5	62,9	59,2	57,2	55,5	53,1	65	55	-15%	19	18	-4%
Effort indicators, 1000 days at sea; days at sea/vessel												
Effort (Total)	194,5	247,5	232,6	219,3	260,6	189,6	225	223	-1%	67	75	12%
Effort (Baltic)	154,6	208,2	195,1	180,3	219,7	147,9	186	183	-2%	55	61	11%
Catch composition, volume, tonnes												
COD in the Baltic	40305	34610	38675	33897	32296	34214	37863	33469	-12%	11,2	11,2	0%
Total in the Baltic	173744	177344	165874	183277	166155	177080	172321	175504	2%	51,0	58,7	15%
Total volume	186093	192293	180356	196132	179933	189754	186247	188607	1%	55,2	63,0	14%
Catch composition, value mln. Eur; Eur/vessel												
COD in the Baltic	51,7	49,8	56,3	54,1	46,6	36,6	53	46	-13%	15,6	15	-2%
Total in the Baltic	91,1	92,9	95,2	100,2	92,0	78,0	93	90	-3%	27,6	30	9%
Total value	123,7	130,0	136,5	145,5	144,8	117,6	130	136	5%	38,5	45	18%

Annex K: spawning timing: Seasonal development of maturity in Baltic cod, with special emphasis on Populations in the Western Baltic (SD 22 and 24)

Introduction

A major concern for fisheries management is the ability to recognize the stock structure of the targeted fish species so that each stock can be optimally managed. Populations expressing different life histories are particularly at risk, as less productive populations may be more vulnerable to overexploitation than more productive populations. Information on stock structure is especially important for fish species that are under high exploitation pressure, like cod in the Baltic Sea.

It is generally known that the recruitment of fish stocks fluctuates and reproduction periods are among the most sensitive phases in the life-cycle of fish in general and cod in the Baltic Sea in particular. The dynamics of recruitment are influenced by both human use and by the environment. A great number of factors play a role, requiring long-term, continuous and interdisciplinary investigations.

Since 1983, ICES has carried out the assessment of the Baltic cod fisheries on the basis of two separate stocks, the western Baltic cod stock *Gadus morhua* L., which is assigned to the western Baltic Sea (ICES subdivisions (SD) 22 - 24) and the eastern Baltic cod stock *Gadus morhua callarias*, which inhabits the area east of Bornholm up to the Bothnian Sea and the Gulf of Finland (ICES SD 25 - 32)(Aro, 2000; ICES 2009). The border between these two stocks is diffuse and mixing occurs (Aro, 2000; Berner and Müller, 1989; Bagge et al., 1994; Oeberst, 2001).

Annual maturation, spawning period and spawning areas of both Baltic cod stocks differ significantly (Wieland et al., 2000; Bleil and Oeberst, 2002; Köster et al., 2005; Bleil et al, 2009). In addition experimental investigations showed that the conditions for successful reproduction of both stocks are different. The lowest salinity limit for the successful fertilization of cod eggs in the central Baltic Sea is 11. Fish from the western stock, in contrast, require a salinity level of 15 for this purpose (Westernhagen, 1970; Nissling and Westin, 1997; Vallin et al, 1999a). Temperatures between 1.5 °C und 10 °C, as well as an oxygen level of at least 2 ml/l are necessary for the development of eggs of both cod stocks.

Thus, in the Baltic Sea, cod spawning areas are separated spatially, because only in the deep basins of the central Baltic Sea and in the deeper areas of the Belt Sea (SD 22) and the Arkona Sea (SD 24) conditions are sufficient for a successful reproduction.

In the last 20 years, the salinity, oxygen and temperature have changed significantly to the disadvantage of stable, successful cod stock reproduction, particularly in the deep basins of the eastern Baltic Sea (Karasiova et al., 2008). The inflow of large amounts of salt water (“major inflow“) that could lead to a drastic renewal of the water layers in the deep basins of the central Baltic Sea has occurred more rarely: The last time such an event happened was in January 2003, following a ten year stagnation period. In ICES SD 22 and 24, comparatively minor saline water inflows took place more frequently in the course of a year. These inflows held the reproductive conditions stable, especially in the ICES SD 22, but were not sufficient to supply the large central Baltic Sea basins with saline and oxygen-rich water.

Adult cod migrate into the spawning areas from their entire distribution area to form pre-spawning and spawning concentrations. With the end of the spawning activities these concentrations dissolve. Spawning and pre-spawning concentrations traditionally represent an ideal possibility for the fishery to attain the highest catches at the lowest cost.

Over the spawning periods, a number of parameters related to spawning and important for recruitment success were observed, such as the duration of the spawning activities, peak spawning, the volumes of eggs spawned as well as the quality of these eggs (egg diameter, dry weight and fertilisation rate) in relation to the parameters of the female cods (length, weight and age) and fluctuating hydrographical conditions (temperature and salinity). The analyses demonstrated that larger and thus older cod release a larger quantity of higher quality eggs over a longer period of time. The release of fertile/developable eggs over the spawning period is assymetrical with a peak shortly after the onset of spawning and a long decline of egg numbers. The quality (weight, size, fertility) of the released eggs reduces continuously from the commencement of spawning through its conclusion (Bleil and Oeberst, 1998). Similar results were described by Solemdal et al, 1993, Kjesbu et al. 1996, Trippel, 1998, Marteinsdottir and Begg, 2002, Scott et al., 2006 for Atlantic cod. It can be concluded that not only the larger portion of eggs capable of development, but also the eggs with the best qualitative perspectives for development are released in the first half of the spawning season. Conservation and protection measures should thus concentrate on this time period. An appropriate timing of measures to protect spawner aggregation is therefore essential to have a maximum positive effect on recruitment while at the same time constrain fishing activities as little as possible.

In the Western Baltic, the targeted cod fishery is prohibited between April 1st and 30th. In the Eastern Baltic, cod fisheries are regulated by a seasonal closure during 1 July to 31 August to protect spawning fish A closure of a central part of the main spawning area in the Bornholm Basin has been implemented and enforced during the main spawning season since the mid-1990s for all fisheries. A year-round area closure for all fisheries in specific areas of the Bornholm Basin, the Gotland Basin and the Gdansk Deep was introduced in 2005 aimed at reducing fishing mortality. Since 2006, area closures have been enforced from 1 May to 31 October (ICES 2009).

This document tries to answer the question which is the optimal time for a fishery closure to protect spawning cod and how variable spawning activities were over the last 20 years (spatially and temporally). The paper also provides suggestions on appropriate future measures which could balance fisher's and conservation needs.

Material and Methods

vTI and its predecessors collect data on cod maturity and spawning timing since 1992, either from commercial catches or from surveys. Cod samples used for this analysis were obtained from in the Belt Sea (ICES SD 22) and the Arkona Sea (ICES SD 24). Data on cod spawning in the Sound (ICES SD 23) were not available.

For this WD, for the period 2000-2010, a total of 117 644 individuals were included in the analysis (ICES SD 22 – n = 49 104; ICES SD 24 – n = 68 540), separated by sex and area. The data of 2009 and 2010 are preliminary. For the whole year 2010 and for the 2nd half of the year 2009 commercial data were not yet available. For a comparison with the time period 1992 – 1999, samples of 52443 fish were used (SD 22 – n = 23 721 SD 24 – n = 28 722).

The potential spawning stock is defined as the total population of fish with a total length greater than or equal to the minimum length at sexual maturity (Berner, 1985; Bleil and

Oeberst, 2002). We have used the minimum length at sexual maturity criteria following the method described by Bleil and Oeberst (2002).

The samples were obtained during international research cruises “BITS” and German national surveys related to the reproduction of cod (CoBalt1-2), which were carried out annually in the Belt Sea (ICES SD 22) and in the Arkona Sea (ICES SD 24) in February, March, May/ June and November from 1992 to 2010. In addition, cod were sampled on research cruises in the southern Mecklenburg Bight (ICES SD 22) during January and December from 1993 to 2007 and in the Arkona Sea (ICES SD 24) during July from 2009 to 2010. Also, samples from German commercial catches were utilized in order to describe seasonal maturity development and spawning activities.

During the research cruises, different bottom trawl nets (“HG 20/25” and “Warnemünder Dorschzeese” and since 2002 “TV3” (following the standard gear specification of the Baltic International Bottom Trawl Survey (ICES, 2002)) were used. Total length, wet weight, age, sex and maturity stage were determined for all individuals. Sexual maturation was determined by visual inspection of the gonads using the 10 stage scale (Tomkiewicz et al., 2003a). For analyses the proportion of individuals in these maturity stages were summarized into four groups:

MS1: preparation (immature and resting)

MS2: pre-spawning (ripening and preparing)

MS3: spawning

MS4: spent

Males and females were analysed separately because the data indicated that the proportion of spawning cod was different between sexes. Single spawning males were observed throughout the year in the potential spawning areas of the Baltic Sea.

Data were also split in “recruit spawners” (total length<35 cm) and “repeat spawners” (total length>=35 cm) because studies of the general annual succession of the spawning processes indicated that the spawning activity in a spawning period always begun with the spawning of oldest/largest cod “repeat spawners”. Smaller individuals follow successively, so that at the end of the spawning period the youngest and smallest fish spawn, also known as “recruit spawners” (Bleil and Oeberst, 1997, 1998).

In the analysis, data from research surveys were given a higher weight as those usually cover the whole distribution area, while commercial fishing targets aggregation of fish at specific times and in specific areas, and quality and price of the landings are additional important factors influencing the behaviour of the fishery. Commercial operations yielded only a limited number of recruit spawners as most of the fish caught was above minimum landing size (38 cm) and thus belonged already to the group of repeat spawners.

As a compromise between maximum temporal resolution and sufficient number of samples per time unit, the analysis used thirds of months (roughly 10 day periods), called “decades” (decade 4 therefore denominates the period Feb 1st through 10th). Fig. K.3 gives all details on number of samples and origin (commercial/survey) by time period.

Results and Discussion

Spawning areas

Belt Sea (ICES SD 22): The deeper regions of Kiel and Mecklenburg Bight, and the Fehmarn Belt (ICES SD 22) with a water depth of 20 m and more (Fig. K.1) are the main spawning regions for cod (Bleil and Oeberst, 2002). The BITS data on the maturity development of cod in the Danish Belt Sea show similar results. The relative proximity to the North Sea and the frequent inflow events provided hydrographic conditions in these areas which are largely sufficient for successful reproduction.

Arkona Sea (ICES SD 24): Spawning activities take place in areas with a depth of more than 40 m (Fig. 1) (Bleil and Oeberst, 2002).

Eastern Baltic Sea (ICES SD 25-32): Cod in the Eastern Baltic have a much larger distribution area than those in the Western Baltic. The deep basins in the Gotland Sea (ICES SD 28), the Gdansk Basin (ICES SD 26), the Slupsk Channel (ICES SD 25) and the Bornholm Basin (ICES SD 25) have traditionally been described as spawning areas (Fig. 1) (Aro, 2000; Karasiova et al., 2008). At present, regular spawning occurs in the Bornholm Basin (ICES SD 25), the deepest part of the Bornholm Sea. This area was described as the recent main spawning area for the cod stock of the Eastern Baltic Sea (Wieland et al., 2000; Tomkiewicz & Köster, 1999; Köster et al., 2005, Karasiova et al., 2008). In all other traditional spawning areas (Fig.1), successful spawning was found only sporadically in the last 15 years. Successful spawning there was clearly related to an inflow of saline and oxygen-rich water in large quantities, leading to a short term improvement of the hydrographical situation (Karasiova et al., 2008).

Timing of spawning

Belt Sea (ICES SD 22): The spawning activities of repeat spawning females currently begins in end of January, peaks from the 2. third of February (Feb 10th) to the 2. third of April (Apr. 20th) and ends at the beginning of June (Fig. K.2). These individuals can be characterized as "spring spawners" (Bleil and Oeberst, 2002).

The spawning activity in 2000 – 2010 differs only slightly from that in the previous century for which data are available (Poulsen, 1930, 1931; Apstein, 1911; Berner, 1960, 1985 and Thurow, 1970).

Total spawning period: 3. decade January – 1.decade June

Main spawning period: 2. decade February to 2. decade April (**decade 5-11, Feb. 10th-Apr. 20th**)

Arkona Sea (ICES SD 24): The Arkona Sea ia a transitional geographic region between the Belt Sea (ICES SD 22) and the Bornholm Sea (ICES SD 25), which are described as typical spawning areas for the western and the eastern Baltic cod stock, respectively. The knowledge about spawning activities in Arkona Sea was inconsistent. Some studies concluded that the Arkona Sea had a minor importance for overall spawning activity, as spawning was sporadic and took place only during spring (Kändler, 1944; Berner, 1960; Berner and Borrmann, 1977; Berner and Vaske, 1981; Bagge et al., 1994). Bleil et al., 2009 demonstrated on the other hand that spawning of cod has occurred in Arkona Sea regularly every year, with a peak during summer in the period 1992 - 2005.

Figure K.2 shows that cod spawning activities take place over a longer period. The proportion of repeat spawning females was high in June and July in the period 2000 – 2010.

Spawning currently begins in the 2. decade of March, peaks from 1. decade of June to 3. decade July and ends in the 2. decade of August (Fig. K.2). From the second half of July however, water temperatures in the area increase so much that it appears unlikely that eggs could still develop regularly.

Total spawning period: 2. decade March – 2. decade August

Main spawning period: 1**.** decade June to 3. decade July **(decade 16 – 21, June 1st-July 31st)**

Spring spawning activity can only be observed to a much lesser extent in the Arkona Sea (ICES SD 24), although with pronounced inter-annual variability. This analysis indicates a shift in the reproduction dynamics of cod in this transition area in comparison to the years before 1992.

Comparison of time periods 2000 – 2010 and 1992 – 1999

The comparison of both time periods indicate no significant changes in the temporal spawning activities in ICES SD 22, although spawning might have started slightly earlier in the last two years.

In ICES SD 24, timing of spawning appears to be even more stable, but the spawning in 2009 was clearly delayed. June remains the month with most spawning activity, but the distinctive spawning activities in May in the 1990-s were not to be observed from 2000 any more. (Figure K.3)

Assessment of current regulations for closed spawning seasons and protection areas for cod

Fishery closures during the most sensitive time periods in the life cycle of cod should be maintained in order to support the production of offspring. The current status of knowledge makes an exact description of the current spawning areas possible.

- Western Baltic (ICES SD 22): The present closed season is in the main spawning period, but mainly protects ”recruit spawners” and not the main spawning potential of the “repeat spawner”. The entire area does not need to be protected uniformly: If enforcement can be ensured, a closure of areas with a water depth of more than 20 m would serve the purpose.
- Arkona Sea (ICES SD 24): The closed season does at present not match the main spawning period. The entire area does not need to be protected uniformly: If enforcement can be ensured, a closure of areas with a water depth of more than 20 m would serve the purpose.
- Bornholm Sea (ICES SD 25): The closed season and protection areas coincide with the main spawning period in the spawning area and should be maintained.

Recommendations for future, optimal closed spawning seasons and protection areas for cod

From this study, the following conclusions are drawn with regard to the definition of closed spawning seasons which would have the most success in securing reproductive success with a general prohibition of cod catches:

- In the Western Baltic (ICES SD 22), sea areas with depths of more than 20 m, from the middle of February to the middle of April,
- in the Arkona Sea (ICES SD 24), the central basin with depths of more than 20 or even 40 m, from beginning of June until the middle of July.

To compensate for the temporal extension of spawning closures, small scale fishing could be permitted provided fishers can fully document that they are not entering areas with more than 20 m water depth during fishing operations.

Generally it can be assumed that the spawning areas do not change over time, but the main spawning periods depend on spawning stock structure and hydrography which can change over time. Regulations on closed spawning seasons should thus be reconsidered in regular intervals and be adjusted if necessary.

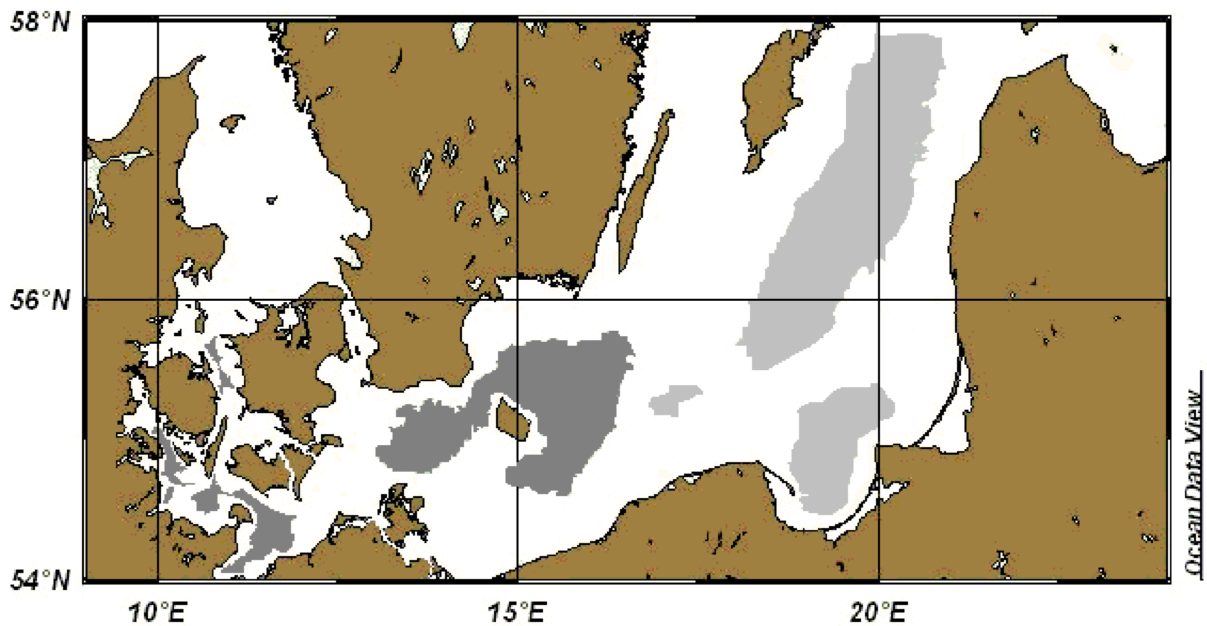


Fig. K.1 Spawning areas of cod in the Baltic Sea (dark-gray – actual spawning areas; gray – historical spawning areas, without regular, annual spawning success in the recent years)

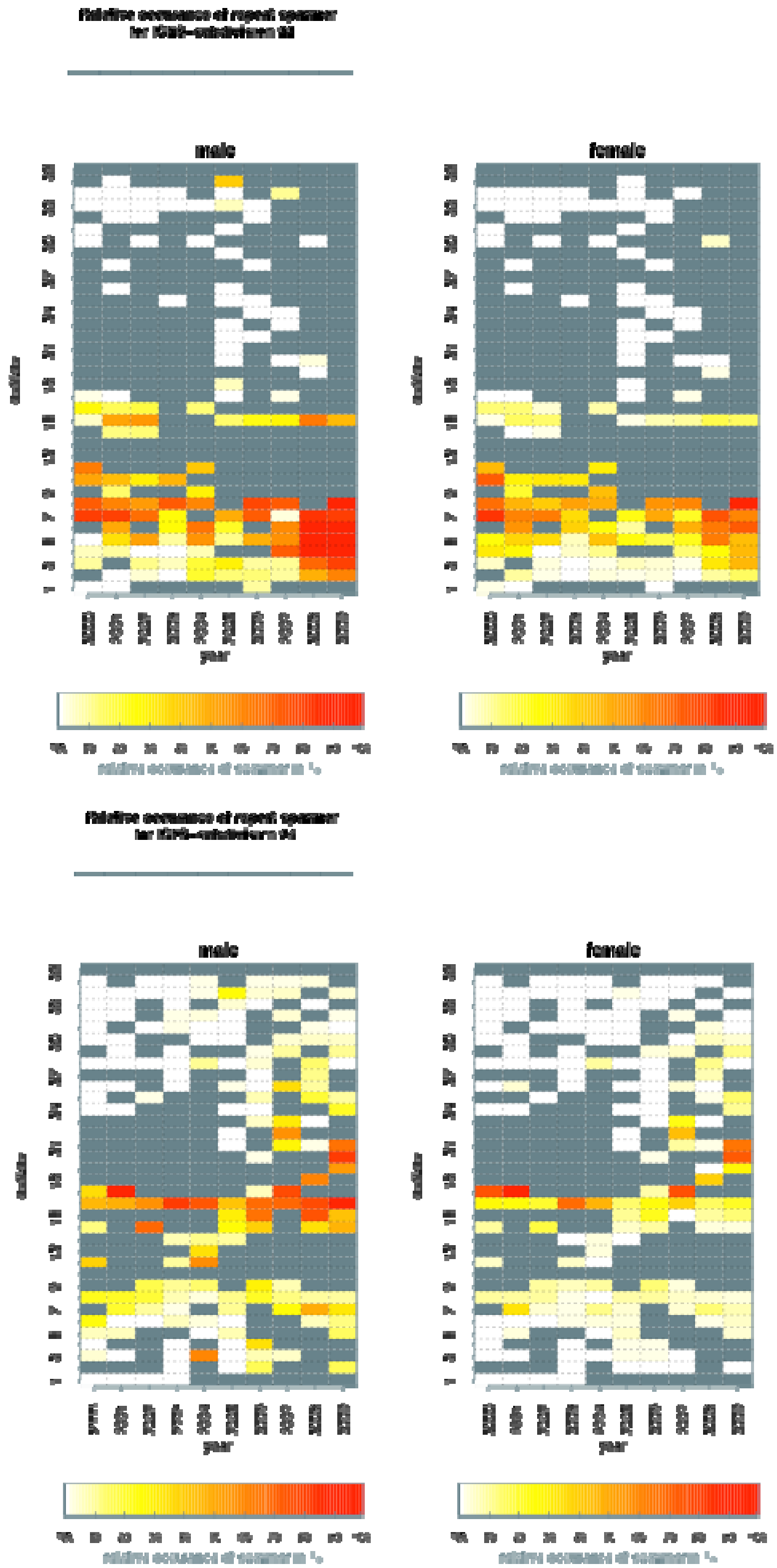


Fig. K.2 Timing of spawning 2000-2009, separately for males/females, SD 22/SD 24 and recruit spawners/repeat spawners, by year and decade (1/3 of a month). Color indicate fraction of spawning fish (white: no spawning, red: 100% spawners, grey: no sample). For number of samples per decade and sample origin see Fig. K.3.

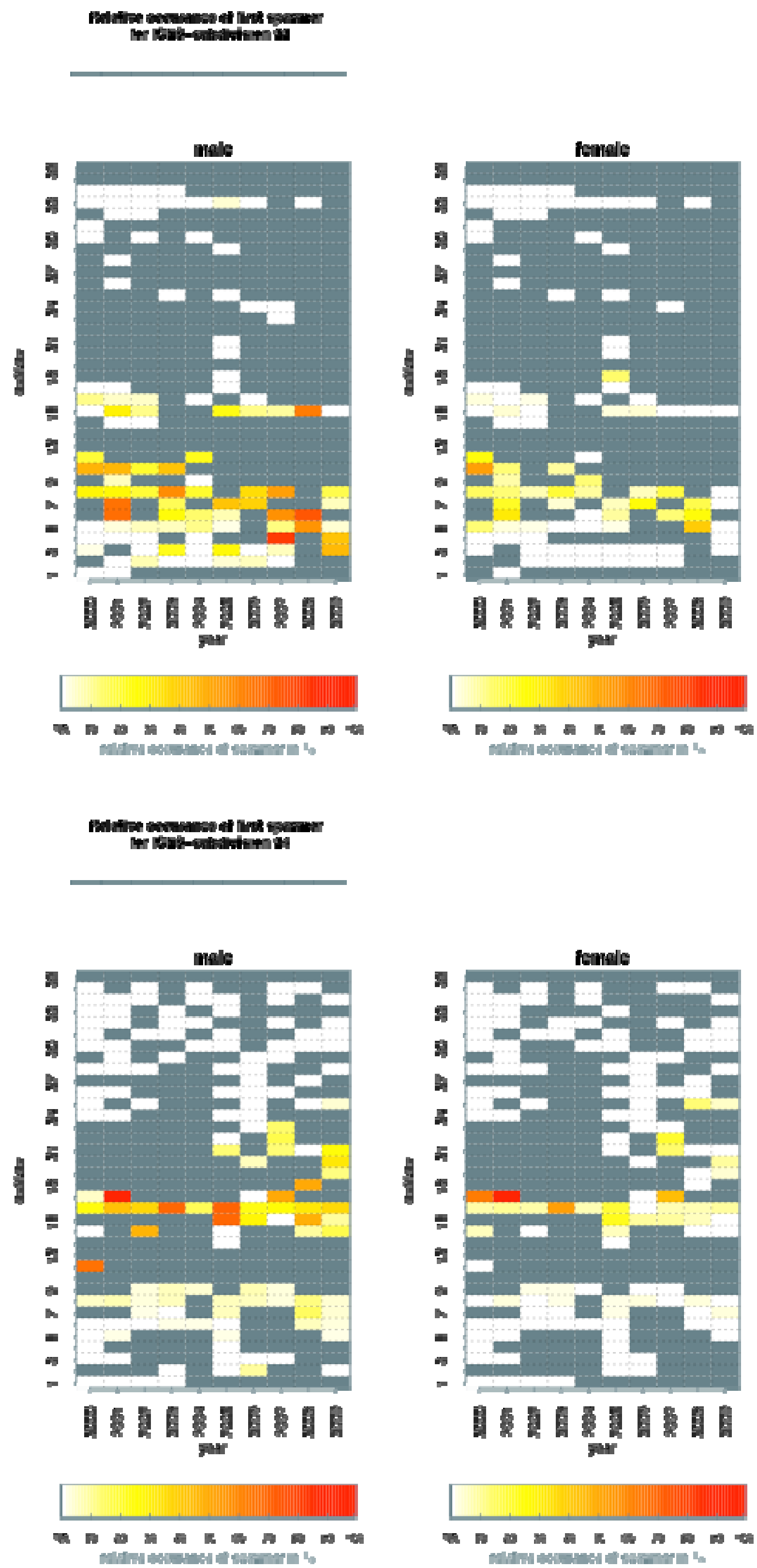
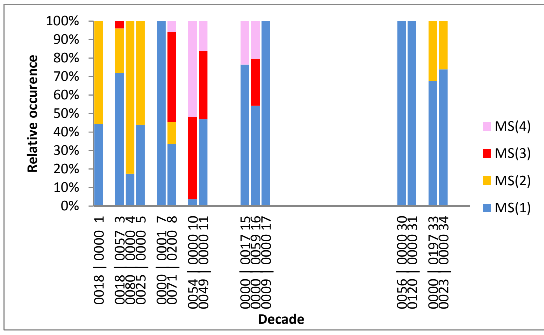
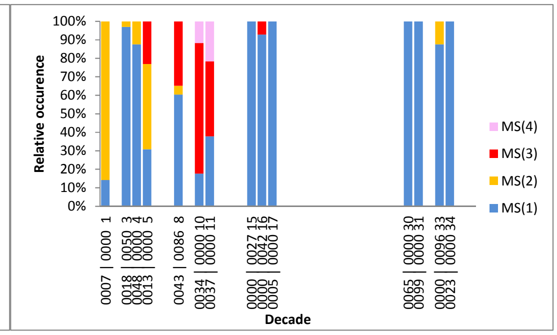


Fig. K.2 Timing of spawning 2000-2009 continued.

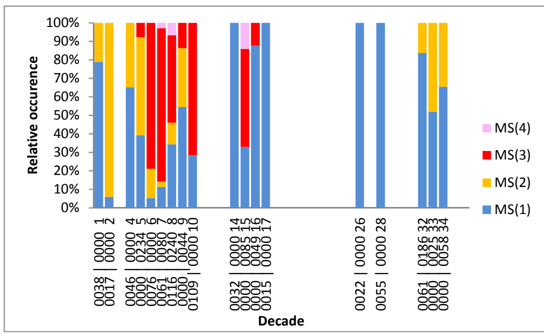
Recuit spawners: SD 22 (Belt Sea)

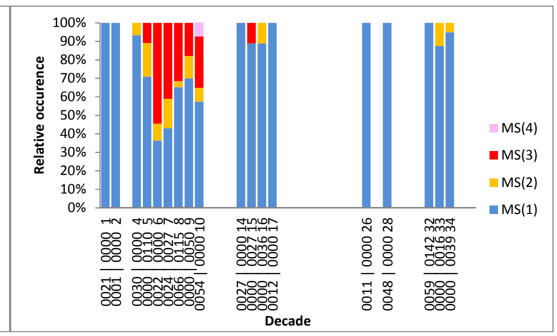
2000 males females



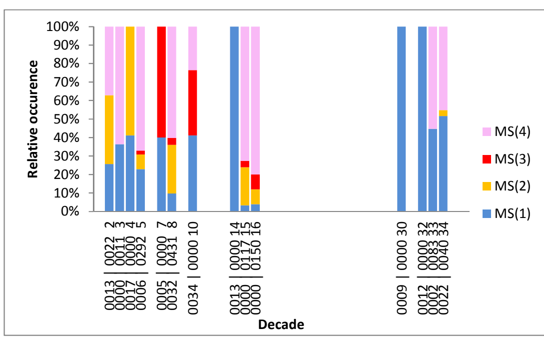


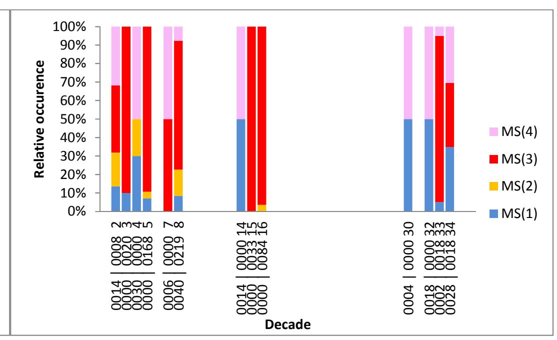
2001 **males** **females**



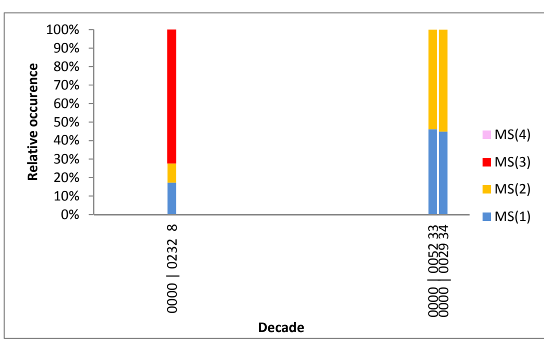


2002 **males** **females**





2003 **males** **females**



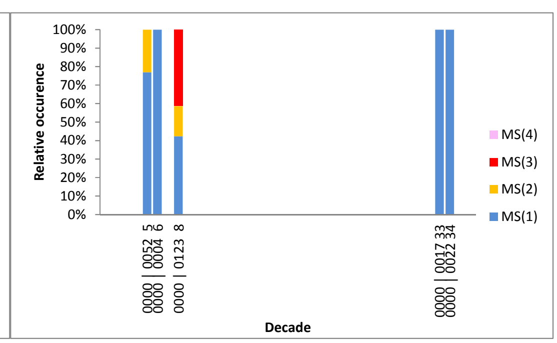
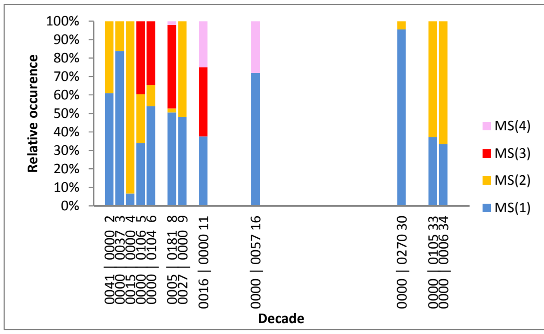
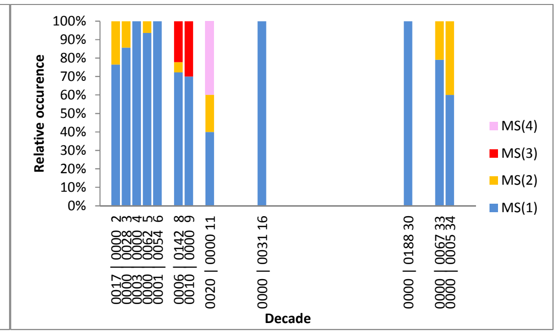


Fig. K.3 Relative occurrence of cod maturity stages by decade (1/3 of a month) 1992-2010, separately for males/females, SD 22/SD 24 and recruit spawners (<35 cm)/repeat spawners (>35 cm). Numbers below the x-axis indicate (from top) the decade, the number of samples from commercial catches and the number of samples from surveys. Blank: no samples available in that decade. 2000-2010 given separately for each year and total over the whole decade, 1992-1999 given as total.

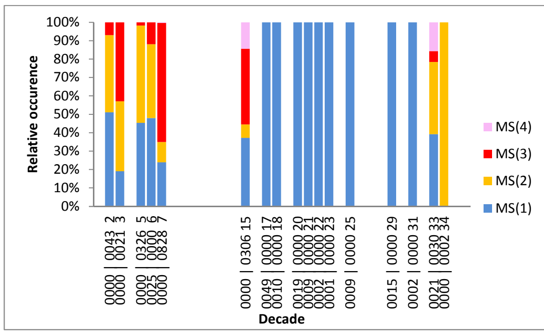
Recuit spawners: SD 22 (Belt Sea)

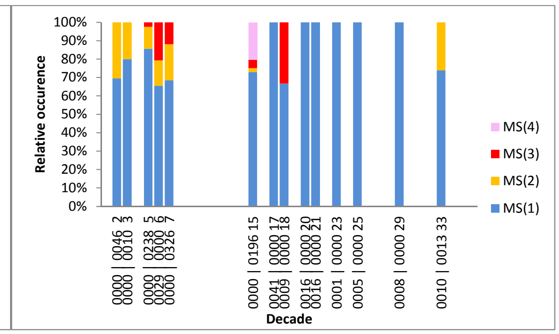
2004 **males** **females**



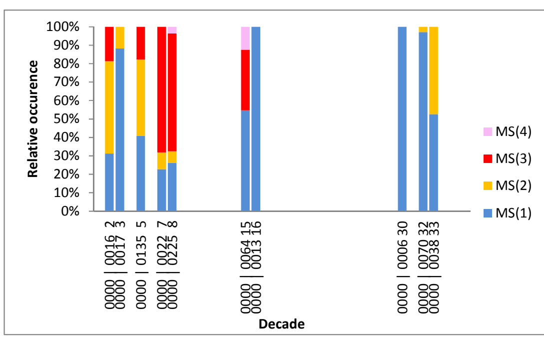


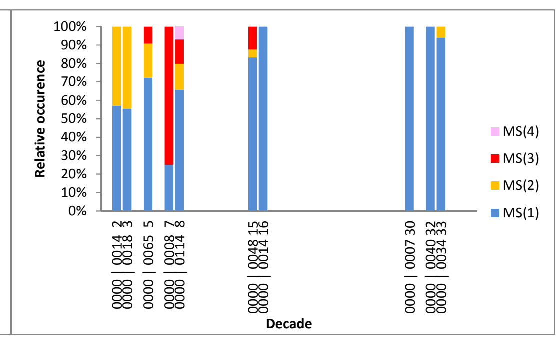
2005 **males** **females**



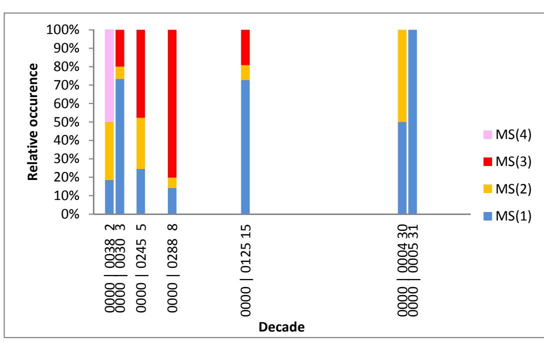


2006 **males** **females**





2007 **males** **females**



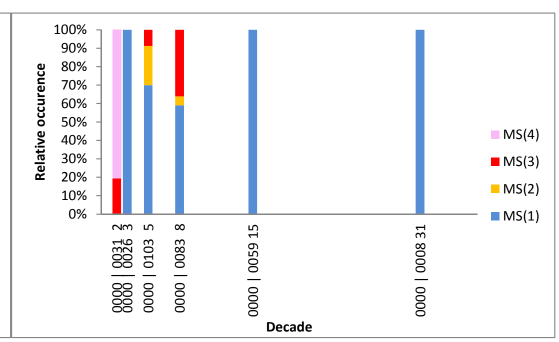
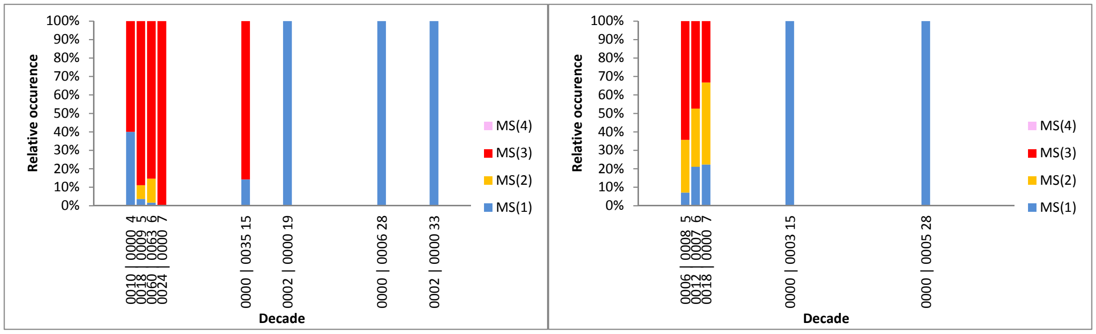


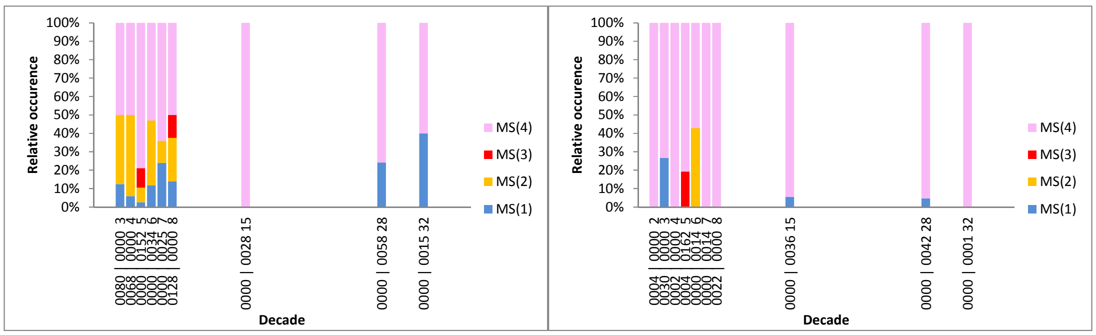
Fig. K.3 Relative occurrence of cod maturity stages…continued

Recuit spawners: SD 22 (Belt Sea)

2008 **males** **females**



2009 **males** **females**



2010 **males** **females**

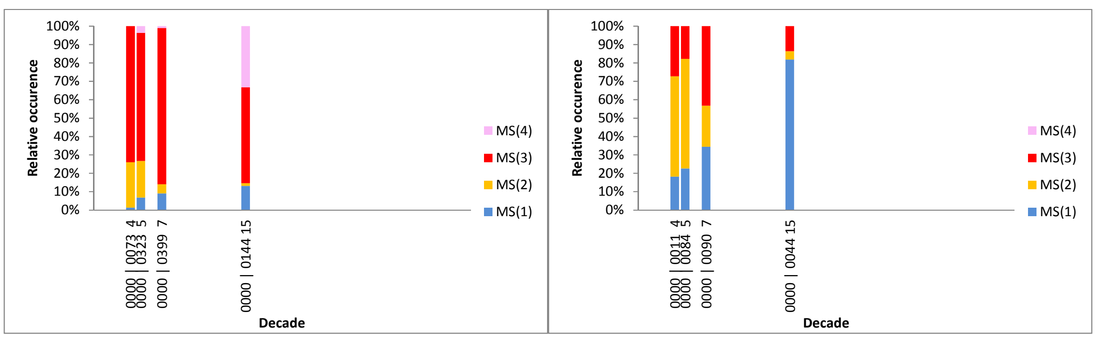
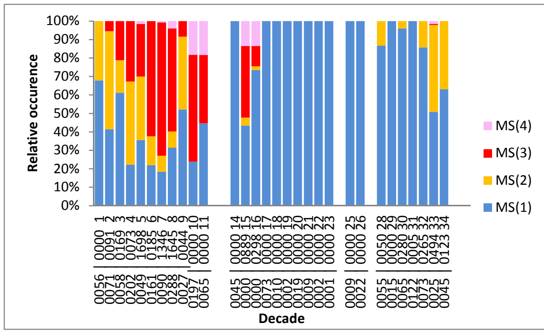
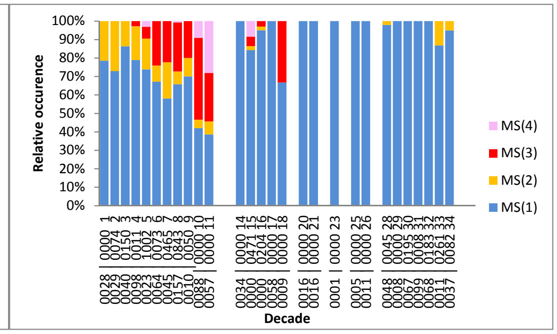


Fig. K.3 Relative occurrence of cod maturity stages…continued

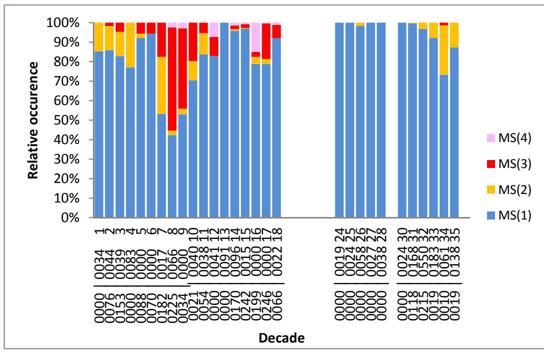
Recuit spawners: SD 22 (Belt Sea)

2000-2010 **males** **females**





1992-1999 **males** **females**



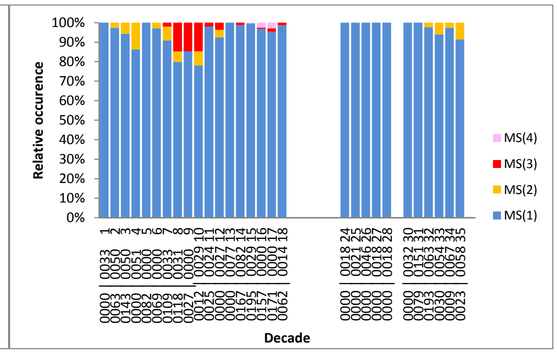
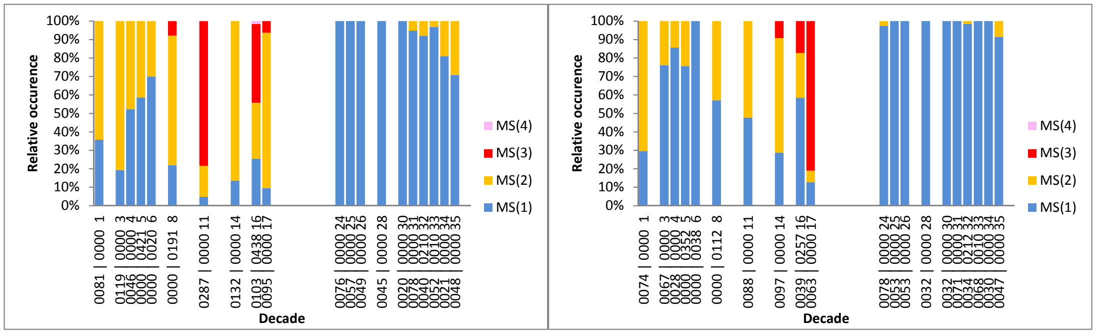


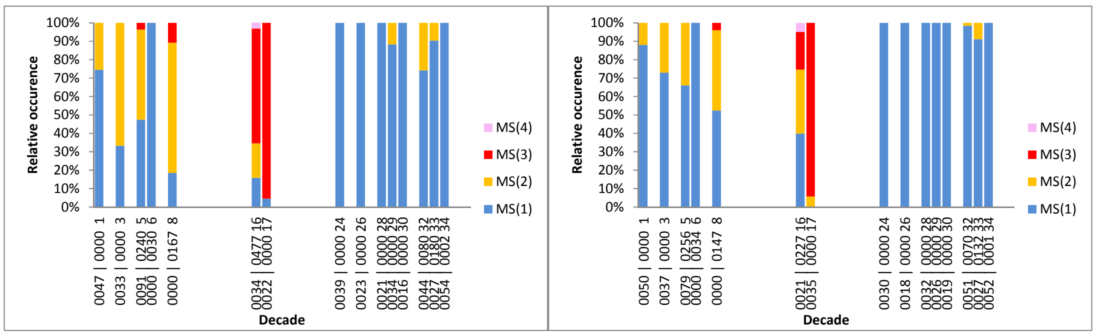
Fig. K.3 Relative occurrence of cod maturity stages…continued

Recuit spawners: SD 24 (Arkona Sea)

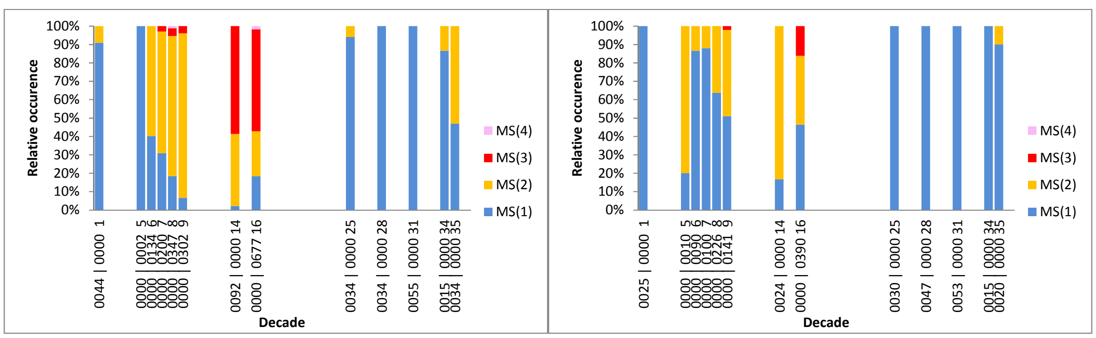
2000 males females



2001 males females



2002 males females



2003 males females

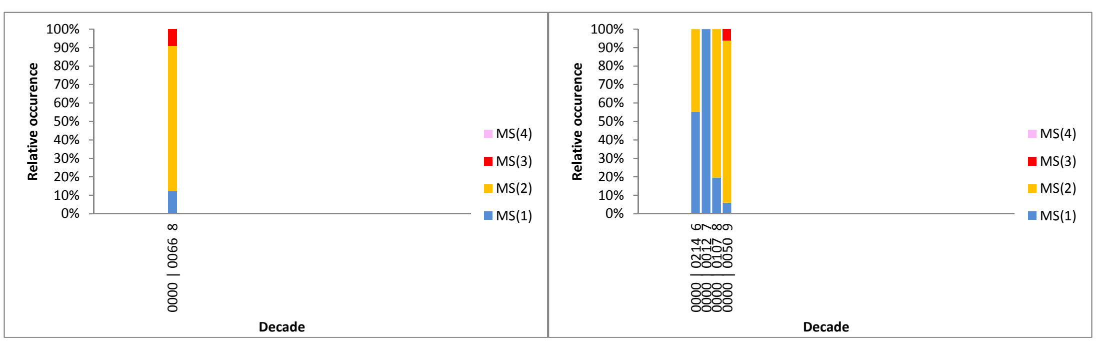
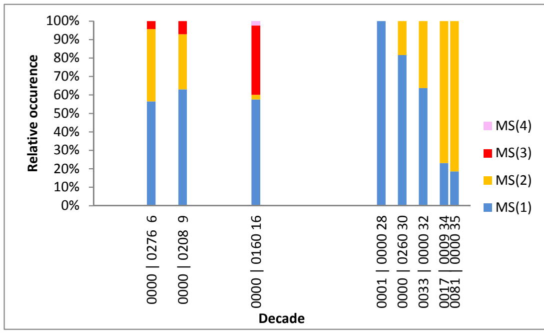
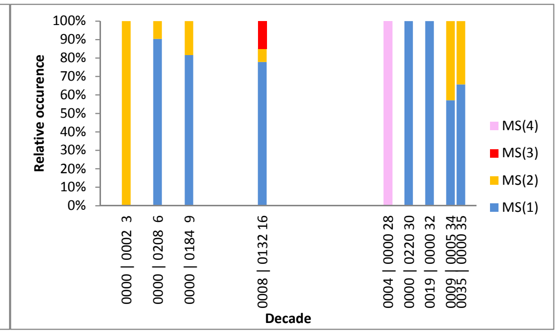


Fig. K.3 Relative occurrence of cod maturity stages…continued

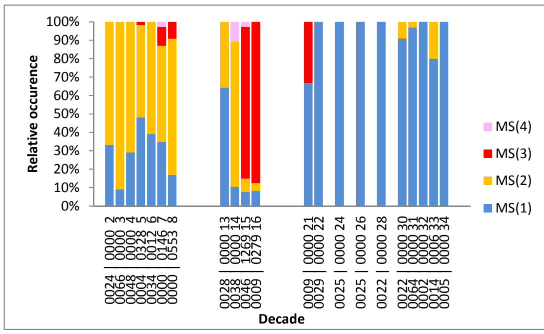
Recuit spawners: SD 24 (Arkona Sea)

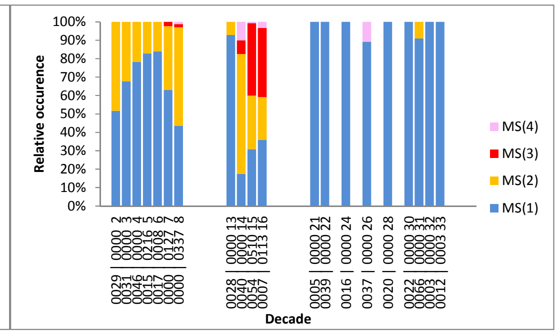
2004 males / females



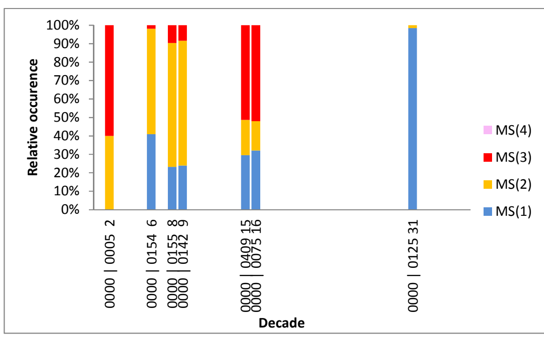


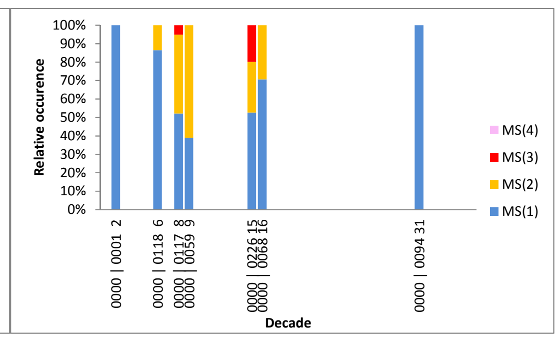
2005 males / females



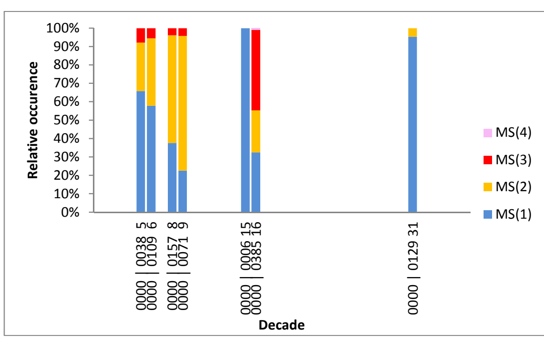


2006 males / females





2007 males / females



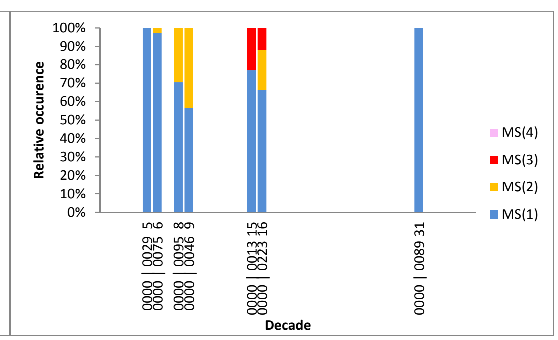
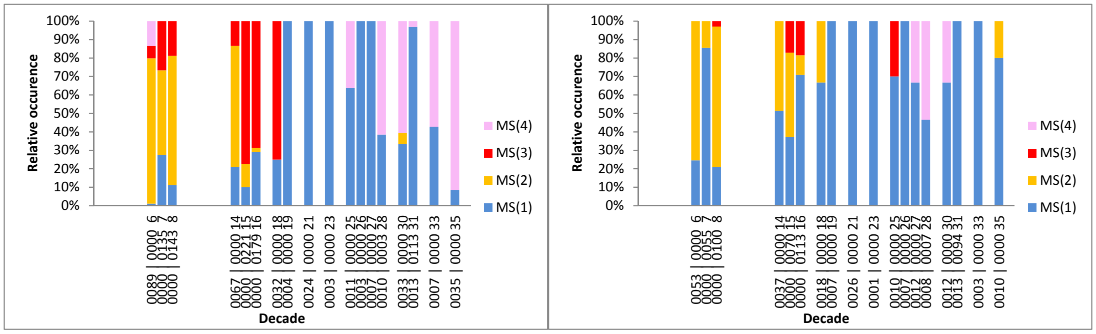


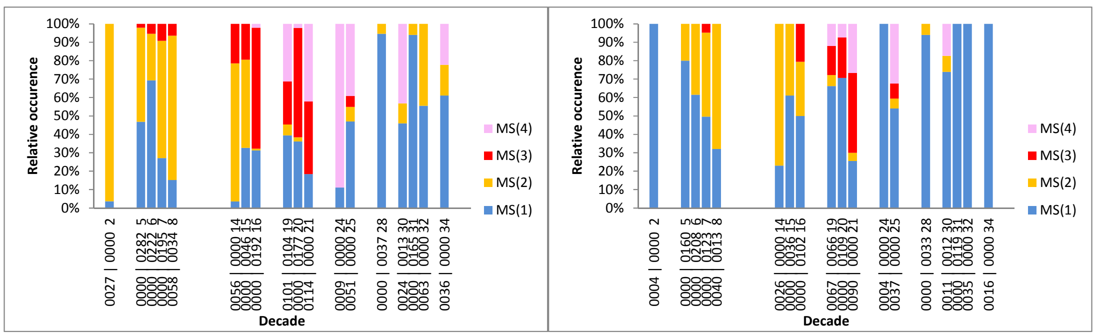
Fig. K.3 Relative occurrence of cod maturity stages…continued

Recuit spawners: SD 24 (Arkona Sea)

2008 **males** **females**



2009 **males** **females**



2010 **males** **females**

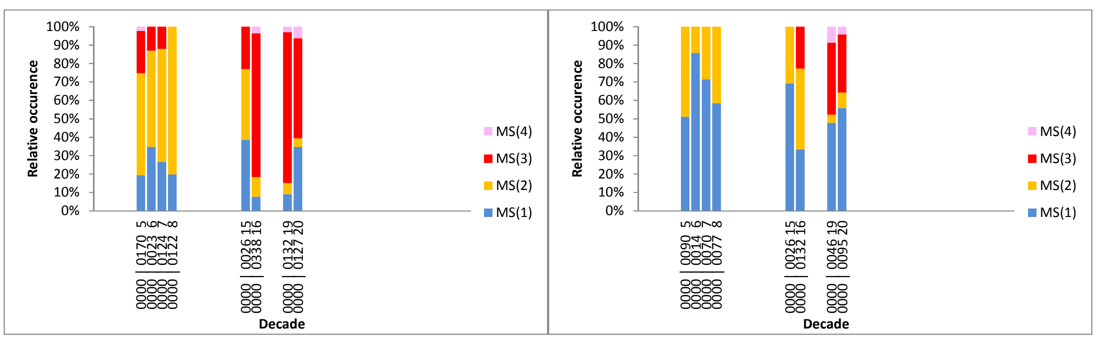
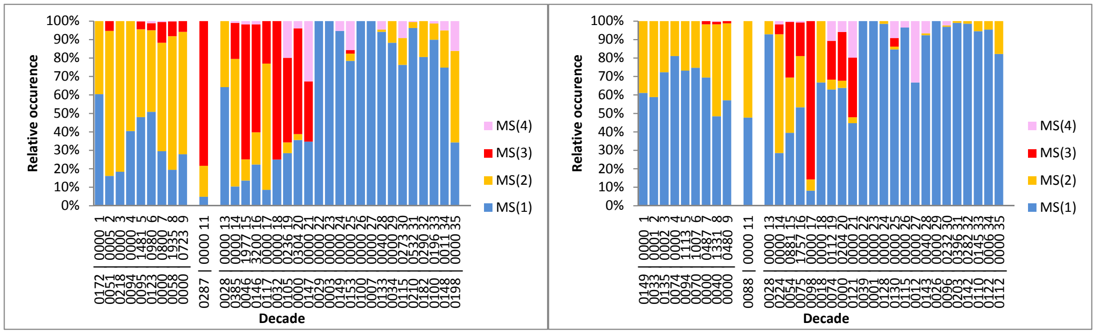


Fig. K.3 Relative occurrence of cod maturity stages…continued

Recuit spawners: SD 24 (Arkona Sea)

2000-2010 **males** **females**



1992-1999 **males** **females**

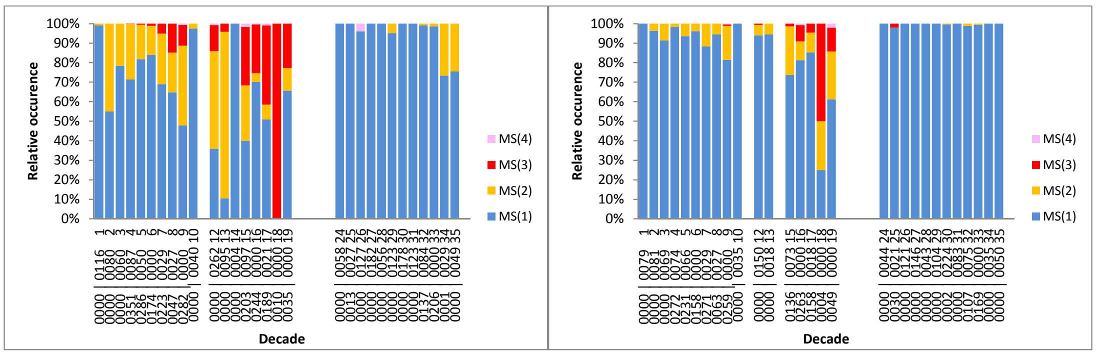
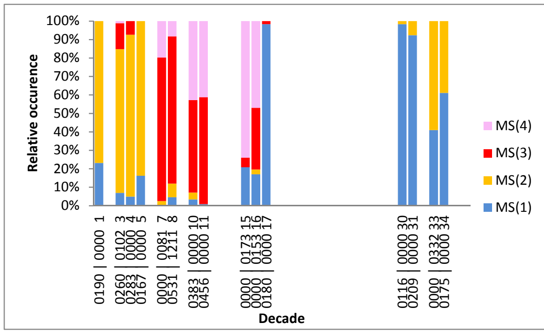
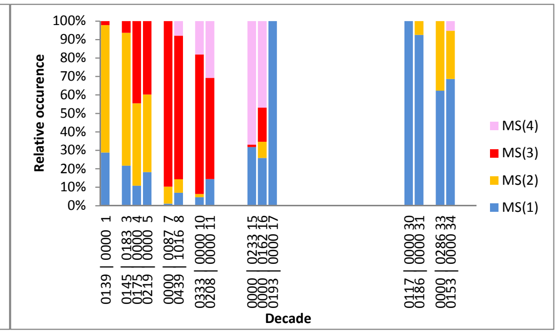


Fig. K.3 Relative occurrence of cod maturity stages…continued

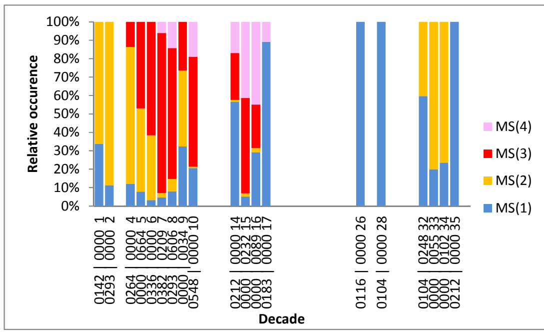
Repeat spawners: SD 22 (Belt Sea)

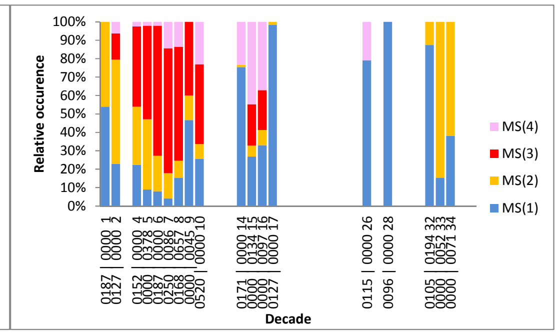
2000 males females



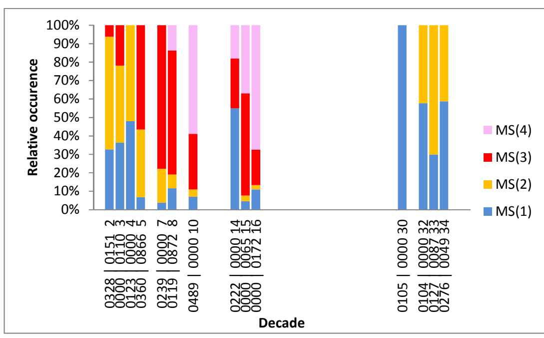


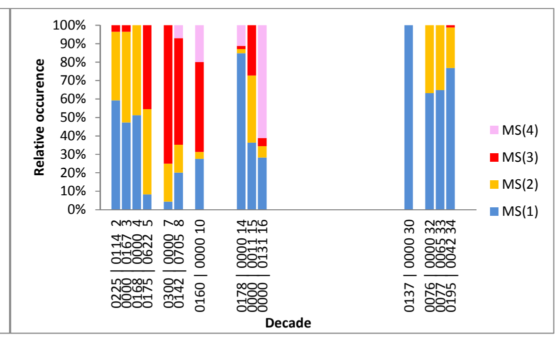
2001 males females



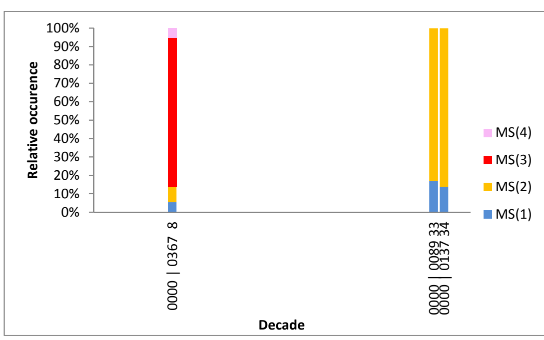


2002 males females





2003 males females



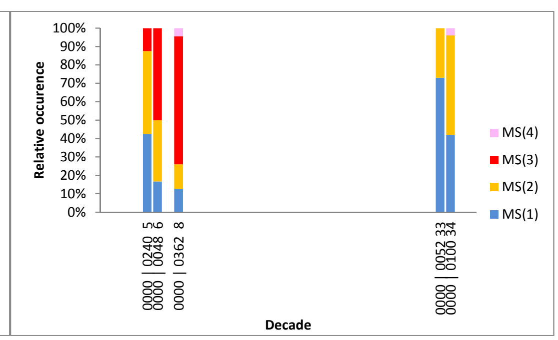
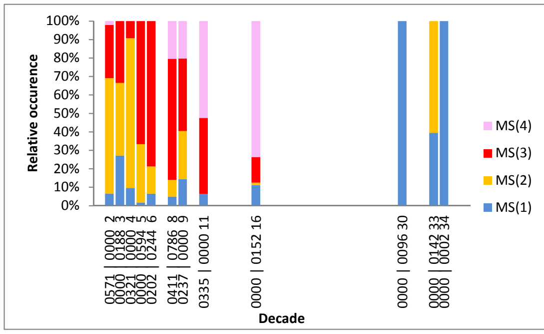
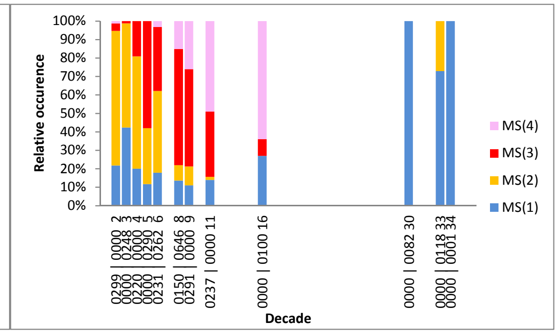


Fig. K.3 Relative occurrence of cod maturity stages…continued

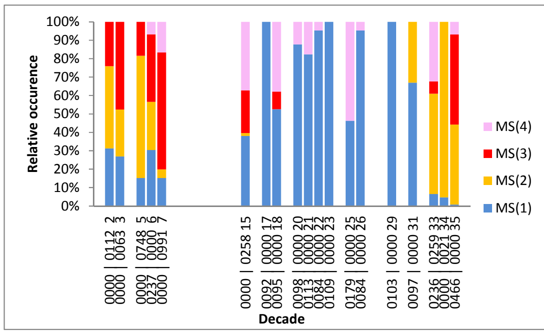
Repeat spawners: SD 22 (Belt Sea)

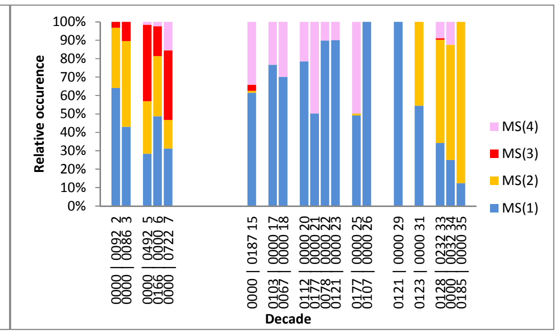
2004 **males** **females**



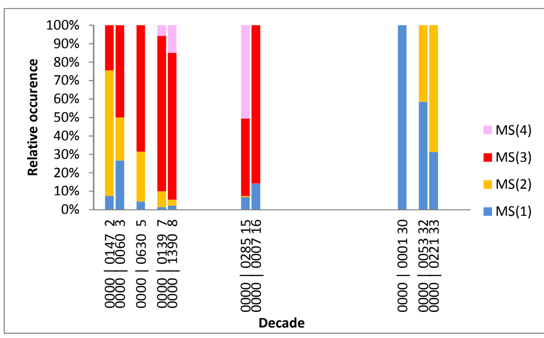


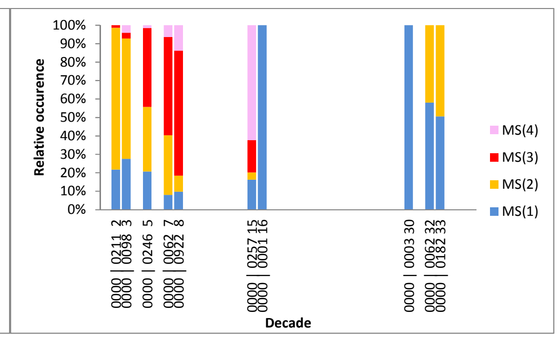
2005 **males** **females**



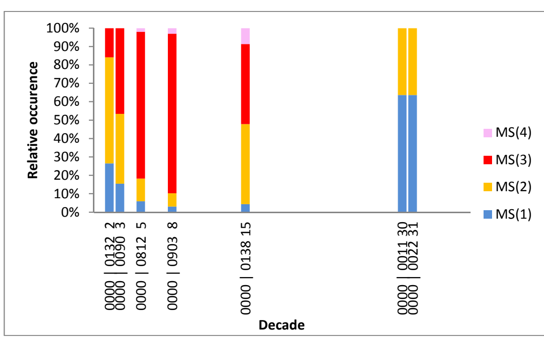


2006 **males** **females**





2007 **males** **females**



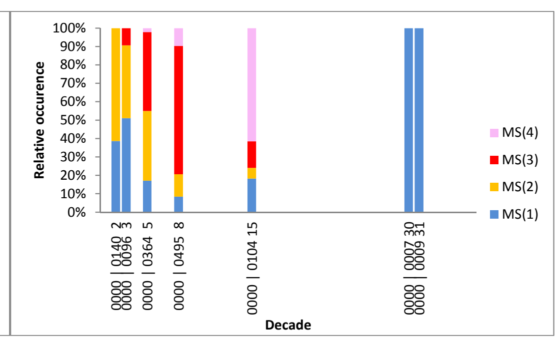
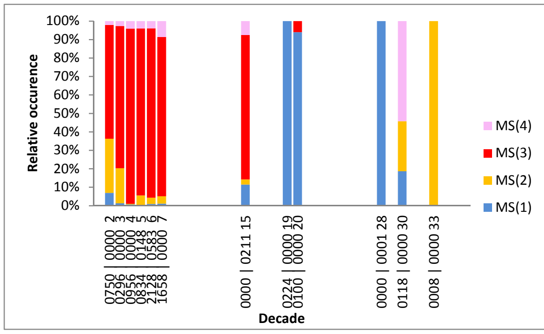
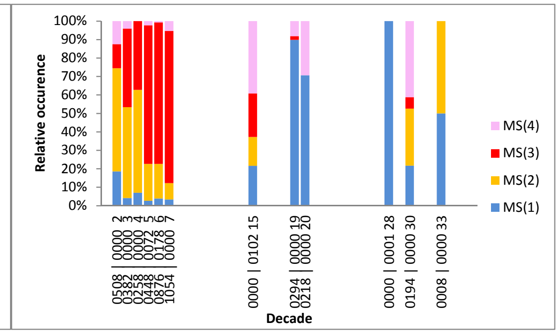


Fig. K.3 Relative occurrence of cod maturity stages…continued

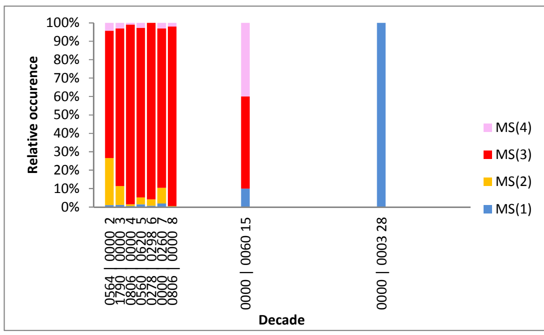
Repeat spawners: SD 22 (Belt Sea)

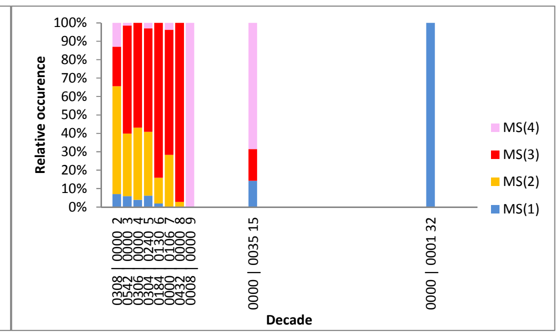
2008 males / females



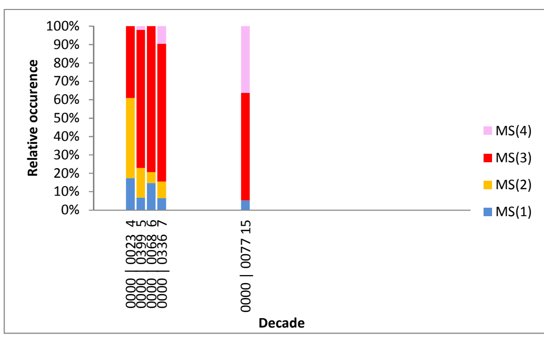


2009 males / females





2010 males / females



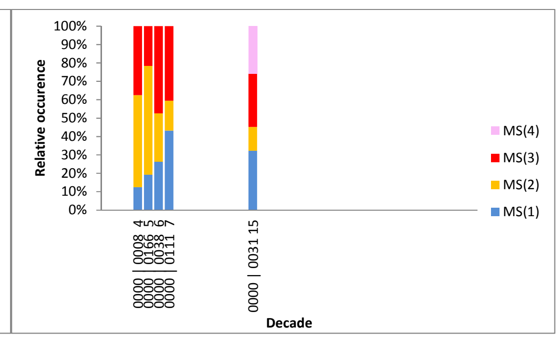
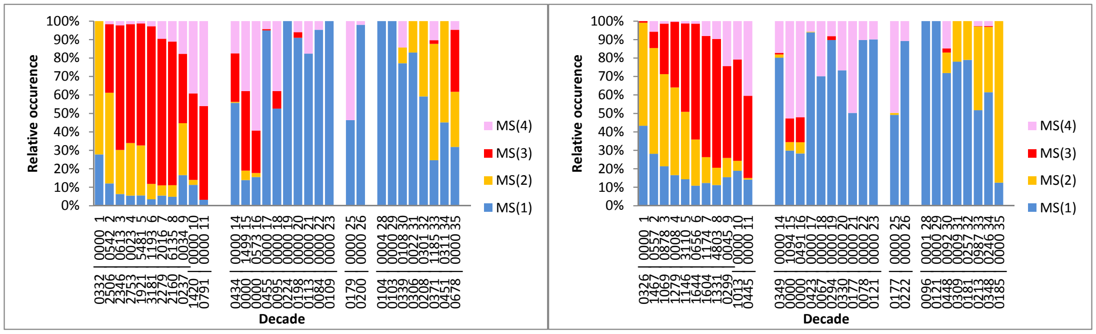


Fig. K.3 Relative occurrence of cod maturity stages…continued

Repeat spawners: SD 22 (Belt Sea)

2000-2010 **males** **females**



1992-1999 **males** **females**

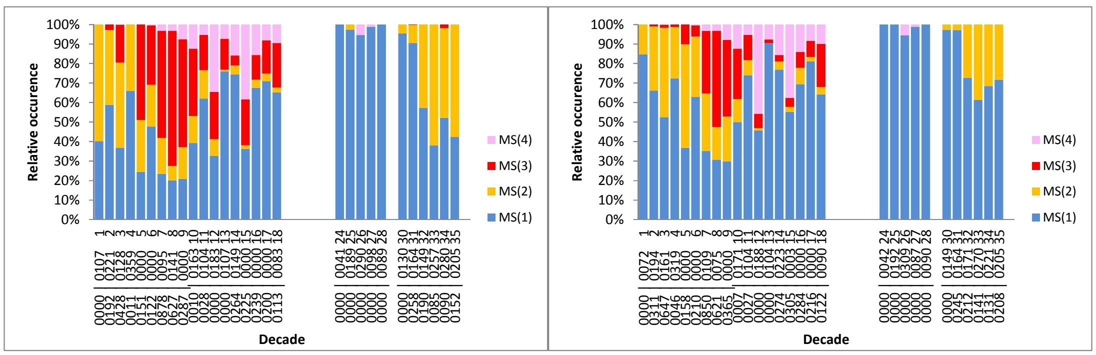
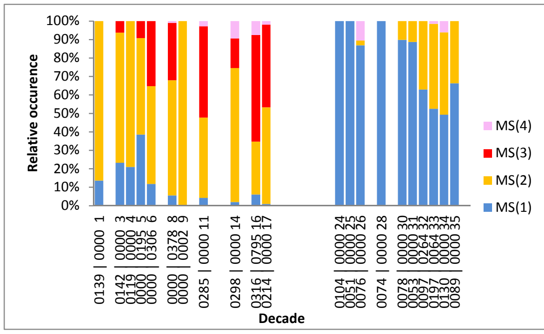
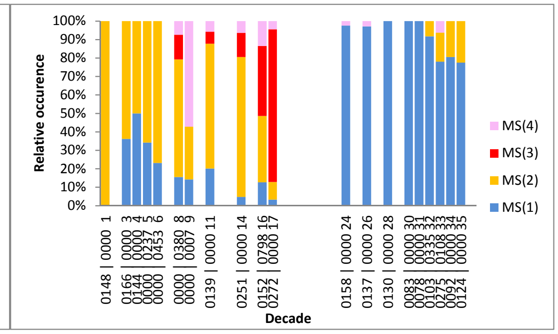


Fig. K.3 Relative occurrence of cod maturity stages…continued

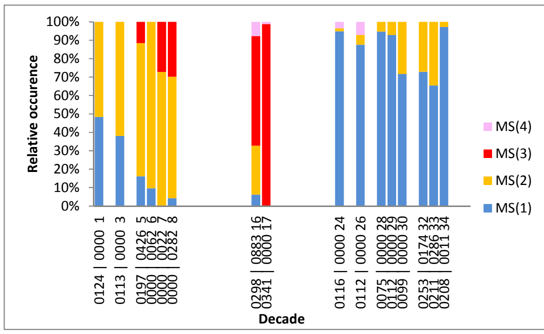
Repeat spawners: SD 24 (Arkona Sea)

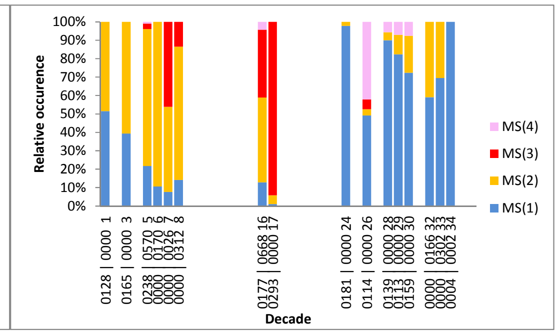
2000 **males** **females**



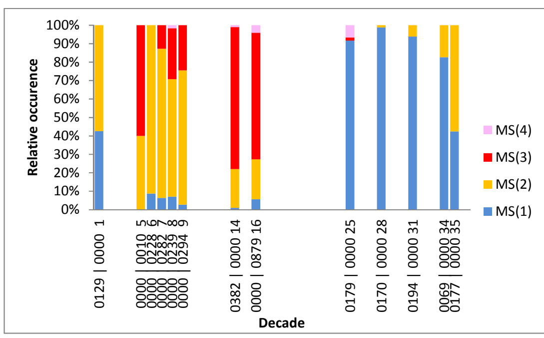


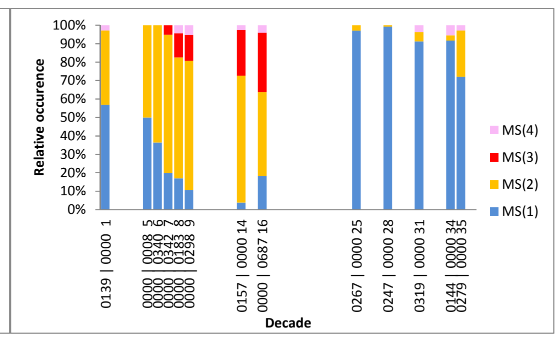
2001 **males** **females**



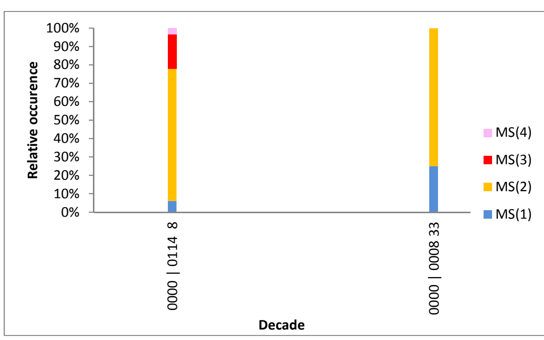


2002 **males** **females**





2003 **males** **females**



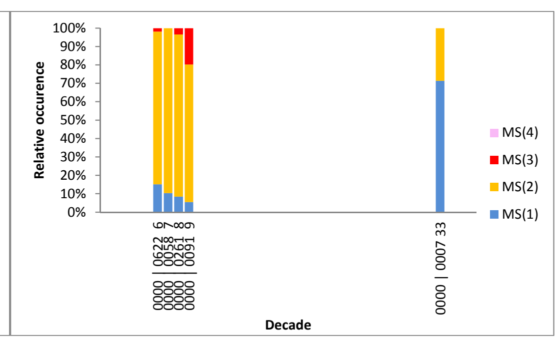
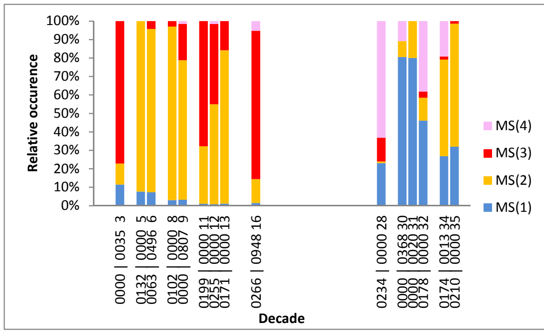
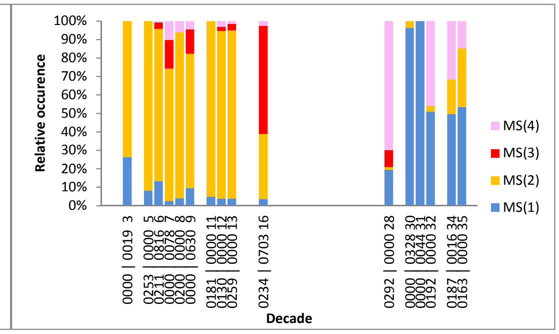


Fig. K.3 Relative occurrence of cod maturity stages…continued

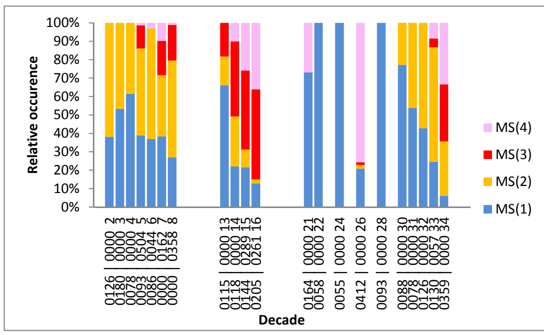
Repeat spawners: SD 24 (Arkona Sea)

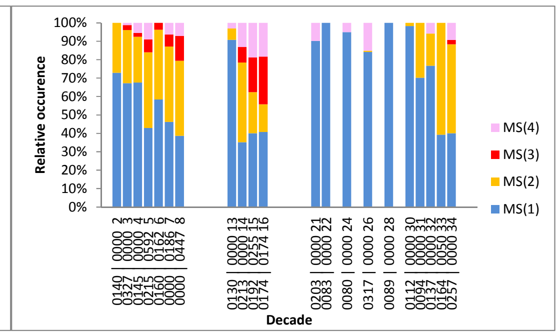
2004 **males** **females**



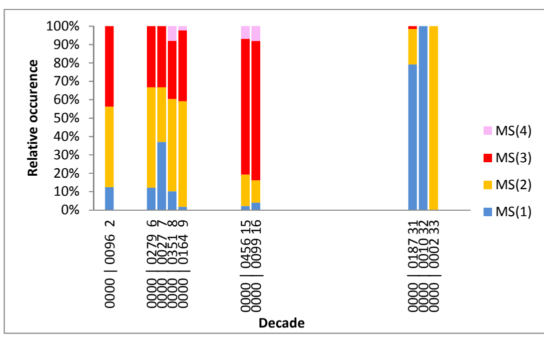


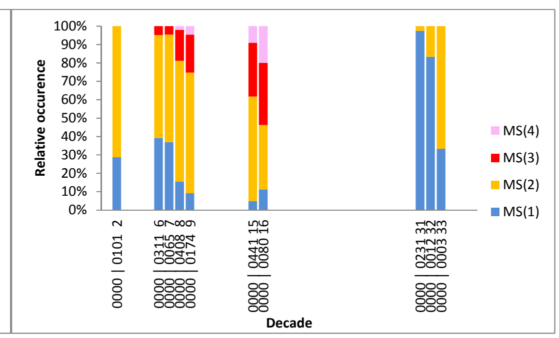
2005 **males** **females**



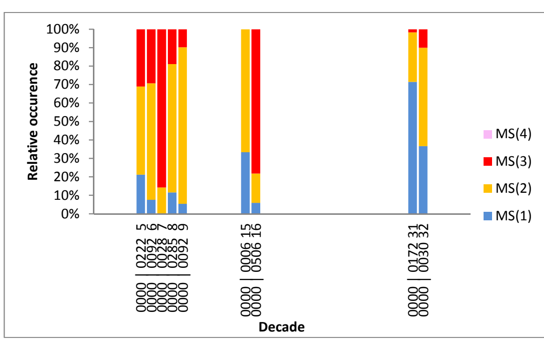


2006 **males** **females**





2007 **males** **females**



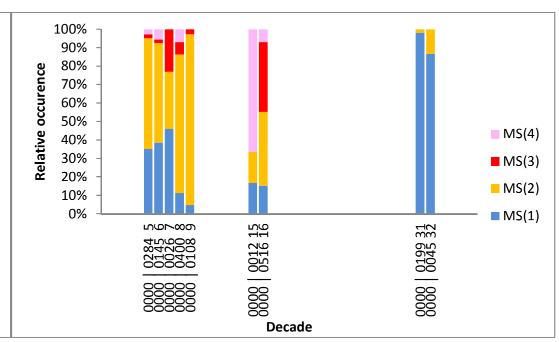
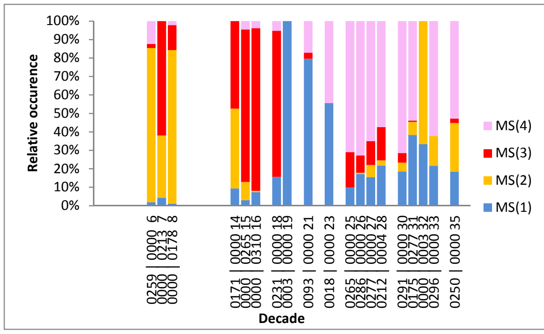
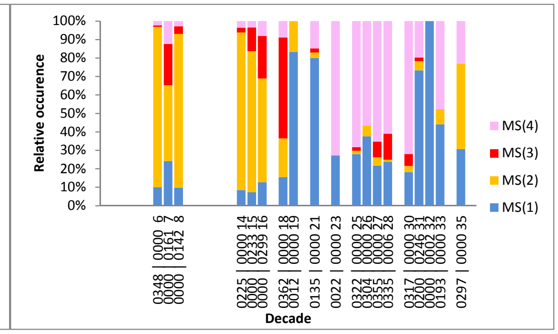


Fig. K.3 Relative occurrence of cod maturity stages…continued

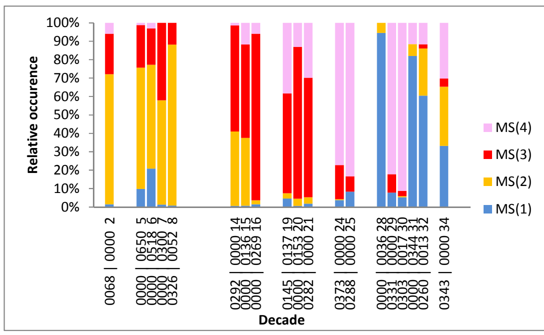
Repeat spawners: SD 24 (Arkona Sea)

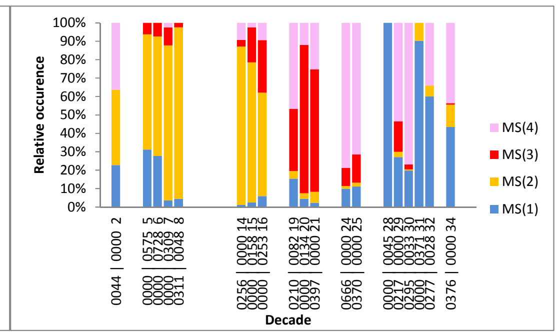
2008 **males** **females**



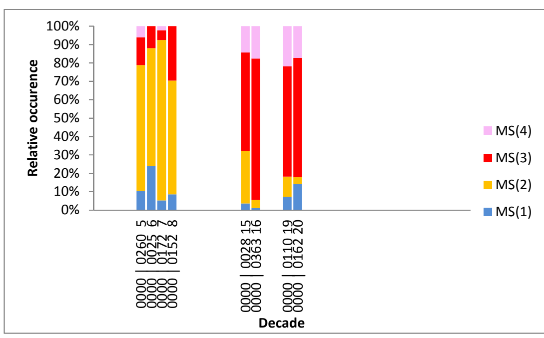


2009 **males** **females**





2010 **males** **females**



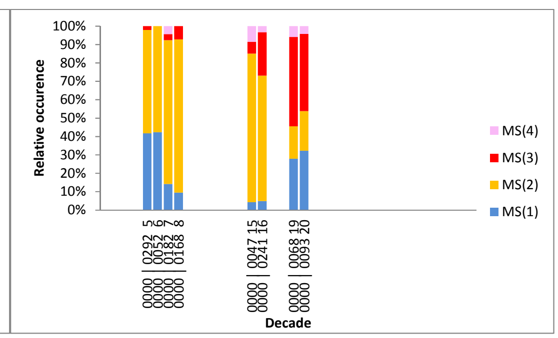
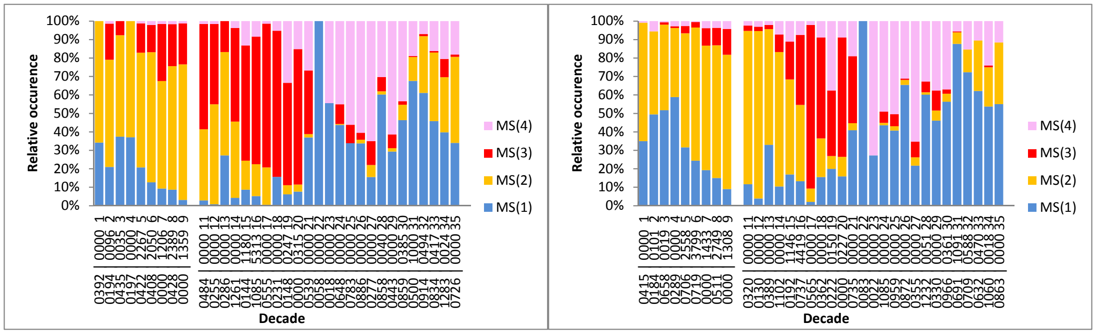


Fig. K.3 Relative occurrence of cod maturity stages…continued

Repeat spawners: SD 24 (Arkona Sea)

2000-2010 **males** **females**



1992-1999 **males** **females**

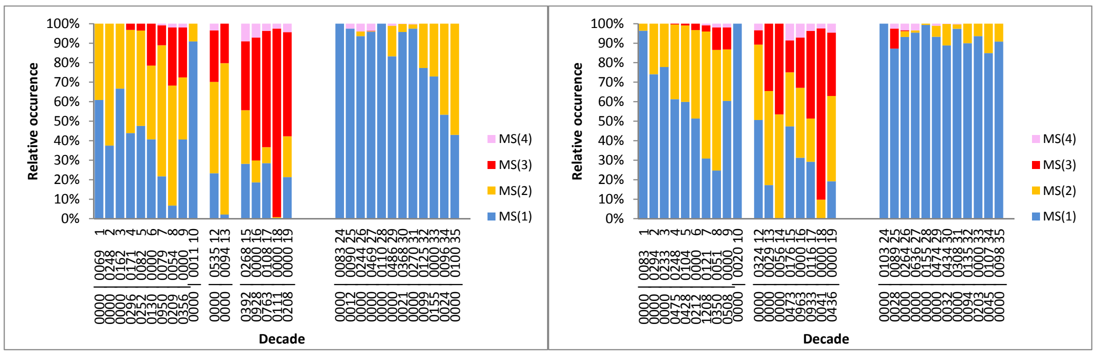


Fig. K.3 Relative occurrence of cod maturity stages…continued

References

Apstein, C., 1911: Die Verbreitung der pelagischen Fischeier und Larven in der Belt See 1908/09. Wiss. Meeresuntersuch. N.F. Abt. Kiel, 1-13.

Aro, E., 2000: The spatial and temporal distribution patterns of cod (*Gadus morhua callarias* L.) in the Baltic Sea and their dependence on environmental variability-implications for fishery management. Academic Dissertation, 1-76.

Bagge, O.; Thurow, F.; Steffensen, E.; Bay, J., 1994: The Baltic cod. Dana **10**, 1-28.

Berner, M.; Müller, H., 1989: Discrimination between „Baltic cod“(*Gadus morhua callarias* L.) and “Belt Sea cod” (*Gadus morhua morhua* L.) by means of morphometric and meristic characters. ICES Counc. Meet. Pap. J 13, 19 pp.

Berner, M., 1985: Die periodische Veränderung der Gonadenmasse und der Laichzyklus des „Ostsee-“ und „Beltseedorsches“ (*G. morhua callarias/ G. morhua morhua*) in verschiedenen Regionen der Ostsee. Fischerei-Forschung **23** (4), 49-57.

Bleil, M., Oeberst, R., 1998a: The spawning of cod (Gadus morhua morhua) under controlled conditions of captivity, quantity and quality of spawned eggs. ICES C.M. 1998/ DD: 3, 27 pp

Bleil, M.; Oeberst, R., 2002: Spawning areas of the cod stock in the western Baltic Sea and minimum length at maturity. Arch. Fish. Mar. Res. **49**, 243–258.

ICES, 2009: ICES Advice 2009, Book 8 The Baltic Sea, 34-40.

Karasiova, E.M.; Voss, R.; Eero, M., 2008:Long-term dynamics in eastern Baltic cod spawning time: from small scale reversible changes to a recent drastic shift. ICES C.M. 2008/ J: 03, 20 pp

Kjesbu, O.S., Solemdal, P., Bratland, P., Fonn, M. 1996. Variation in annual egg production in individual captive Atlantic cod (Gadus morhua L.). Can. J. Fish. Aquat. Sci.,1996, Vol. 53, 610-620

Köster, F. W.; Möllman, C.; Hinrichsen, H.-H.; Wieland, K.; Tomkiewicz J.; Kraus, G.; Voss, R.; Makarchuk, A.; MacKenzie, B.R.; St. John, M.A.; Schnack, D.; Rohlfs, N.; Linkowski, T.; Beyer, 2005: Baltic cod recruitment – the impact of climate variability on key processes. ICES Journal of Marine Science **62,** 1408-1425.

Oeberst, R., 2001: The importance of the Belt Sea cod for the eastern Baltic cod stock. Arch. Fish. Mar. Res. **49**, 83-102.

Poulsen, E. M., 1930: On the fluctuations in the abundance of cod fry in the Kattegat and the Belt Sea and causes of the same. Rapp. Proc. Verb. Cons. Int. Explor. Mer. **65**, 26-34.

Poulsen, E. M., 1931: Biological Investigations upon the cod in Danish Waters. Meddelelser fra Kommissionen for Danmarks Fiskeri og Havundersögelser **IX**, 1-32.

Marteinsdottir, G., and Begg, G.A. 2002. Essential relationships incorporating the influence of age, size and condition on variables required for estimation of reproductive potential in Atlantic cod, *Gadus morhua*. Marine Ecology Progress Series 235: 235–256.

Nissling. A; Westin, L., 1997: Salinity requirements for successful spawning of Baltic and Belt Sea cod and the potential for cod stock interactions in the Baltic Sea. Mar Ecol. Prog. Ser. **152,** 261–271.

Scott, B. E., Marteinsdottir, G. A., Begg, G. A., Wright, P. J., and Kjesbu, O. S. 2006. Effects of population size/age structure, condition and temporal dynamics of spawning on reproductive outout of Atlantic cod (*Gadus morhua*). Ecological Modelling 191: 383–415.

Solemdal, P., Berg, Ö., Dahle, G., Falk-Petersen, I.B., Fyhn, H.J., Grahl-Nielsen, O., Haaland, J.M., Kjesbu, O.S., Kjørsvik, E., Loken, S., Opstad, I., Pedersen, T., Skiftesvik, A.B. 1993. Thorsen, A.: Size of spawning of Arcto-Norwegian cod and the effect on their eggs and early larvae. ICES C.M. 1993/G: 41

Thurow, F., 1970: Über die Fortpflanzung des Dorsches *Gadus morhua* (L.) in der Kieler Bucht. Ber. Dt. Wiss. Komm. Meeresforsch. **21**, 170-192.

Tomkiewicz J.; Köster, F. W., 1999: Maturation process and spawning time of cod in the Bornholm Basin of the Baltic Sea: Preliminary results. ICES Counc. Meet. Pap. Y 25, 11 pp.

Tomkiewicz, J., Tybjerg, L. and Jespersen, Å. 2003a. Micro- and macroscopic characteristics to stage gonadal maturation of female Baltic cod. Journal of Fish Biology 62: 253−275.

Trippel, E.A., 1998: Egg size and viability and seasonal offspring production of young Atlantic cod. Transaction of the American Fish. Soc. 127: 339-359

Vallin, L., Nissling, A., Westin, L. 1999a: Potential factors influencing reproductive success of Baltic cod, *Gadus morhua,* a review. Ambio **28**, 92-99.

Westernhagen, H.v., 1970: Erbrütung der Eier von Dorsch (*Gadus morhua*), Flunder (*Pleuronectes flesus*) und Scholle (*Pleuronectes platessa*) unter kombinierten Temperatur und Salzgehaltsbedingungen. Helgoländer wiss. Meeresunters. 21: 21–102, 1970

Wieland, K.; Jarre-Teichmann, A.; Horbowa, K., 2000: Changes in the timing of spawning of Baltic cod: possible causes and implications for recruitment. ICES Journal of Marine Science **57**, 452-464.

ANNEX L: DECLARATIONS OF EXPERTS

Declarations of invited experts are published on the STECF web site on https://stecf.jrc.ec.europa.eu/home together with the final report.

European Commission

EUR 24628 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: Scientific, Technical and Economic Committee for Fisheries. Report on the meeting on Multi-annual Plan Evaluations Impact Assessments: d) Evaluation of multi-annual plan for Baltic cod.

Author(s): John Simmonds, Heleen Bartelings, Jörg Berkenhagen,,Jose Maria Da Rocha Alvarez, Margit Eero, Leyre Goti, Joakim Hjelm, Tore Jakobsen, Sven Kupschus, David Miller, Arina Motova, Rasmus Nielsen Tom Peatman, Tiit Raid, Robert Scott, Cristina Silva, Valentin Trujillo, Willy Vanhee and Christopher Zimmermann

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Abstract

This report is one five parts of the report of SG MOS 10-06, the STECF sub group on management objectives and strategies dealing with historic Evaluations of and future Impact Assessments of multi-annual plans for fisheries. In total five separate reports are prepared by STECF-SGMOS 10-06 WGs, the first, scoping meeting report STECF-SGMOS 10-06a, contained preparatory work, the other four report the individual assessments:-

STECF-SGMOS 10-06b Report of the Impact Assessments for North Sea plaice and sole multiannual management.

STECF-SGMOS 10-06c Report of the Impact Assessments for Western Channel sole multiannual management.

STECF-SGMOS 10-06d. Report of the Evaluations of Southern hake and Nephrops Multi-annual plan

STECF-SG MOS 10-06e. Report of the Evaluations of Baltic cod Multi-annual plan

This report describes an evaluation of the performance of the multi-annual plan for fisheries of Baltic cod.

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